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PRODUCT IMPROVEMENT PROGRAM EVALUATION

Boeing Vertol Company
(A Division of The Boeing Company)
Philadelphia, Penn. 19142

June 1977

Final Report for Period 17 May 1976 - 17 February 1977

Prepared for
EUSTIS DIRECTORATE
U. S. ARMY AIR MOBILITY RESEARCH AND DEVELOPMENT LABORATORY
Fort Eustis, Va. 23604

EUSTIS DIRECTORATE POSITION STATEMENT

This report presents the results of an effort to develop a general technique for evaluating potential aircraft modifications. The technique considers improvements in reliability, maintainability, and capability, and provides measures of life-cycle cost and operational effectiveness. A computer program was produced to implement the analysis technique; this report also serves as documentation for that program.

The technique presented should prove useful in evaluating proposed product improvements and in establishing research priorities in terms of benefits achieved, costs incurred, and risks assumed.

Timothy D. Evans and Robert L. Walker, Military Operations Technology Division, were the technical monitors for this project.

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This report presents the results of a study to develop an analysis technique for evaluating the cost and operational effectiveness of potential aircraft modifications that affect reliability and maintainability.

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SUMMARY

Throughout an aircraft's life cycle, various product improvements are recommended to upgrade the vehicle's reliability and maintainability characteristics. The problem for program managers lies in deciding whether the cost of improving the aircraft will be sufficiently offset by the reductions in expenditures for maintenance that are expected to result if the improvements are made. Rigorous analysis techniques that consider all of the variables involved in such decisions were not always used in the past, either because they were not available or were not easily utilized.

The purpose of the program described in this report was to develop a technique for evaluating the cost and operational effectiveness of potential aircraft modifications that affect reliability and maintainability. The methodology developed was to consider the vehicle changes in the context of a task accomplishment approach. In other words, the change was to be evaluated in terms of its ability to perform a specific mission. A further aim was to make the evaluation technique easily useable by those involved in the decision-making process.

Task I consisted of the development of a computer program to evaluate proposed aircraft R&M changes with respect to a baseline configuration. Several cost techniques such as break-even point, rate of return, and net present worth were used. Output included the following cost categories: research and development, investment nonrecurring and recurring, and operational costs. The program allowed analysis between implementation cost and change-to-operational cost. Furthermore, the program permitted assessment of the change in effectiveness in terms of availability, utilization, and fleet size. The results of the first task were documented in an interim report.[1]

Task II called for the construction of several test cases to be run through the computer program. Historical data on modifications of selected components was examined to determine the impact of the modification on aircraft operations and costs.

The result of the project was a new, integrated technique for evaluating potential aircraft modifications, which considers R&M improvements and measures cost and operational effectiveness within a task accomplishment structure. Although this study was undertaken with aircraft in mind (particularly helicopters), there are no limiting factors in the technique which will not allow its application to other vehicles or systems.

[1]Blewitt, S. J., PRODUCT IMPROVEMENT PROGRAM EVALUATION, The Boeing Vertol Company, Philadelphia, Pennsylvania, Boeing Document D210-11146-1, November 1976.

PREFACE

This report presents the results of a study to develop a generalized analysis technique for evaluating potential aircraft modifications, which may result from the successful completion of advanced R&D programs. The study was conducted under Contract DAAJ02-76-C-0020 for the Eustis Directorate, U. S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia.

USAAMRDL technical direction was provided by Mr. T. Evans, Mr. R. Walker, and Mr. H. Bratt.

The Project Engineer for the Boeing Vertol Company was Mr. S. J. Blewitt of Product Assurance Research and Development. Program management and technical direction were provided by K. G. Rummel and K. T. Waters.

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INTRODUCTION

In addition to the capacity for achieving greater levels of reliability early in the life cycle of aircraft through aggressive development programs, substantial reliability growth potential is present during the in-service and production phases. Where continued product improvement efforts have been applied, significant reductions in failure or removal rates have resulted. An integral component of any product improvement program is a method for quickly and conclusively determining the most beneficial changes that could be incorporated into in-service aircraft. Program managers are faced with a variety of field problems, proposed changes and possible improvements suggested by a multitude of sources. The proposed changes offer a wide range of benefits and incorporation costs, [illegible] within the framework of the ever-shrinking defense b[illegible].

There is [illegible]easing awareness that high system reliability can be obtained through a growth process of test-analyze-fix, which is repeated through the system's life cycle. As the system passes through the design and development phases into full production, changes become increasingly expensive to make. This is due to the cost of retrofit for any modification which cannot be installed at the time of production. A choice is involved between producing kits to be sent out to the field for installation on all the aircraft and waiting for the aircraft to be returned for overhaul for installation of the modified part. An additional alternative is to allow the system to continue operating at present levels with its associated costs.

In the past, proposed aircraft modifications were generally evaluated based on the number of failures or the quantity of manhours spent on the repair of a certain part. One way or another a component rose toward the top of a problem list and began receiving attention. Depending on the seriousness of the problem or the amount of funds available, the item was chosen for improvement, and an engineering change proposal was initiated. In some cases, a cost analysis was done to show that the cost of redesign and incorporation could be offset by savings later on through decreased removals and maintenance manhours expenditures. The process by which one candidate was chosen over another was not always rigorous or consistent. Furthermore, the resultant changes in operational effectiveness were not readily quantified.

The purpose of this report is to document a general technique for evaluating potential modifications to existing aircraft systems. The procedure requires background analysis and the preparation of computer program input, execution of the program with variation of the input parameters, analysis, interpretation and display of the results. The technique permits the evaluation of a proposed change in the context of a task accomplishment structure; that is, it is considered in light of the aircraft's mission. A potential modification is compared to a baseline configuration to quantify the effect of reliability and maintainability changes on availability, utilization, fleet size and cost. The technique is an inexpensive tool suitable for general application to the product improvement decision-making process.

UNDERSTANDING PRODUCT IMPROVEMENT

Reliability can be improved by increasing the length of time that a piece of hardware will operate without failing. Maintainability can be upgraded by decreasing the length of time it takes to perform a maintenance task or by reducing the number of men required to perform a repair, both of which lower total maintenance manhours. Generally, improving R&M results in fewer failures and maintenance manhours, and a reduction in the number of spare parts that must be kept in the inventory. All of this equates to lower cost. Furthermore, since the aircraft spends less time in the hangar, it is available for use more often and can accumulate more flight time. However these benefits can only be achieved at a price. An improvement in R&M has a cost and this must be offset by lower operating costs in the future or improved operational effectiveness. In addition, R&M benefits sometimes carry a penalty of increased weight or reduced performance which must also be counterbalanced.

OPERATIONAL EFFECTIVENESS

It is postulated that each type of aircraft has a characteristic availability/utilization relationship associated with it. Availability is defined here as the percentage of calendar hours in a given period that an aircraft is not undergoing maintenance. For example, in a 28-day month of 672 hours, if the aircraft were down for maintenance 67.2 hours, it would have been available for use 90% of the time. The 67.2 hours of maintenance were generated because the aircraft flew a certain number of hours, which required inspections to be performed and failures to be repaired. As the aircraft flies more, it requires more maintenance and consequently has a lower availability percentage. Another aircraft type with better R&M features would also have a characteristic availability/utilization relationship, but on a higher level. This concept is illustrated in Figure 1, with the first aircraft depicted in curve A and the second represented by curve B. For the same availability, aircraft B achieved more flying time because it generated less maintenance per flight hour.

Going a step further, if a series of these curves were added to Figure 1 for various levels of R&M improvement, one could develop a plot of increased utilization capability as a function of R&M level for constant availability. This, of course, is based on the assumption that all other things will be equal, such as number of mechanics, tools and support equipment. This concept is illustrated in Figure 2. As can be seen, utilization per aircraft increases with higher levels of reliability and maintainability.

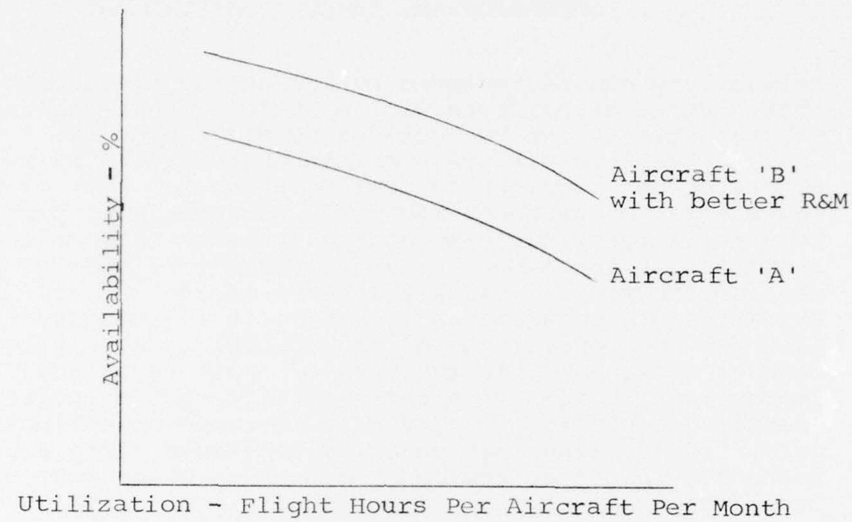

Figure 1. Availability Versus Utilization

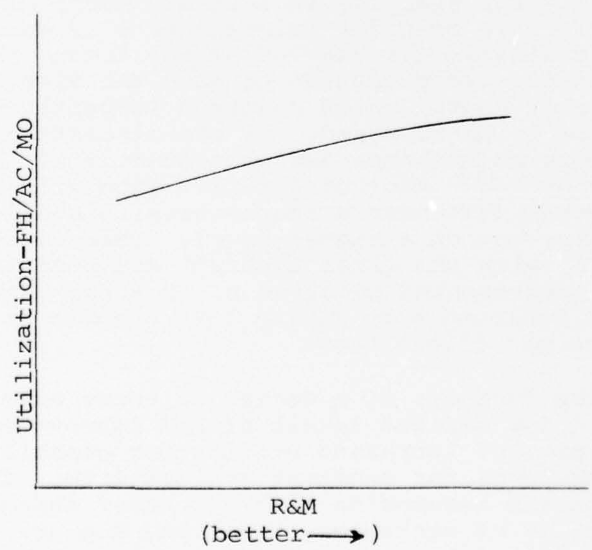

Figure 2. Utilization Versus R&M

If better R&M permits aircraft to achieve more flying time, then this benefit must be quantifiable in terms of the aircraft operator's resources. Assume that a mission is defined that requires a fleet of aircraft of a certain type to fly 7000 hours in a month. This could have been calculated based on the loads to be carried and the capability of the aircraft. Assume further that this type of vehicle can achieve 50 flight hours per aircraft per month (FH/AC/MO) at a certain desired availability level. Then 140 aircraft would be needed to complete the mission (7000 hours divided by 50 hours per aircraft). Now, if another aircraft with better R&M could achieve 70 flight hours per aircraft per month, only 100 of this type would be needed. Figure 3 illustrates this principle. If utilization per aircraft is increased, the fleet size required to perform the same task is reduced.

This section showed how the relative operational effectiveness of an R&M improvement can be measured, in the context of the program described in this report. Better R&M can result in higher aircraft utilization and a smaller fleet size, but, as was stated previously, not without cost.

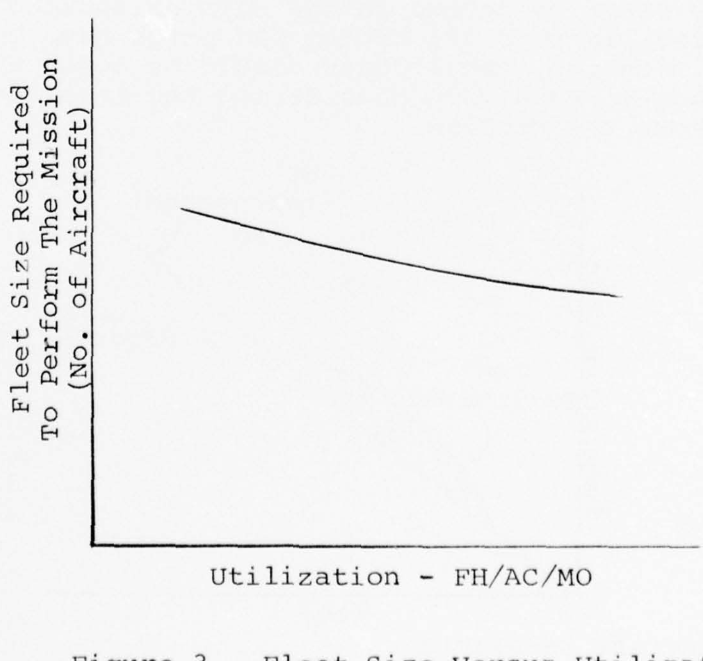

Figure 3. Fleet Size Versus Utilization

COST EFFECTIVENESS

In-service aircraft as a group generate maintenance at a fairly predictable rate. This is obvious in the case of scheduled maintenance and inspections, but perhaps less so in the case of unscheduled maintenance or failures. Nevertheless, as experience is gained and the fleet accumulates hours, it becomes apparent that many components continue to fail at a constant rate over the life of the aircraft. This assumes that the aircraft are past the infant mortality or early failure stage and have not yet reached the wearout phase. Consequently, dollar expenditures are accumulating at a constant rate over time. At some point, a recurring component problem may be identified as a candidate for modification, perhaps because it is a big contributor to downtime, because it is a high cost item, or because its failure rate is getting worse. Whatever the reason, a decision is made to improve the hardware in order to lower the total operating cost. Obviously some amount of investment will have to be made, to design the change, test and qualify it, and incorporate it into the fleet. Sometimes new tooling is required to produce the changed parts. At any rate, total costs are going to be higher during this period than they would have been if no improvement had been made. This is because the old parts are still failing and being repaired with their associated costs while funds are being spent on developing the new parts. Gradually, the improved parts get incorporated into the fleet, and the benefits of the higher reliability start to accrue in the form of reduced operating cost. Ultimately when all of the old parts have been replaced by the modification, total costs should be lower than they were previously, even when considering the investment required. Figure 4 shows the process.

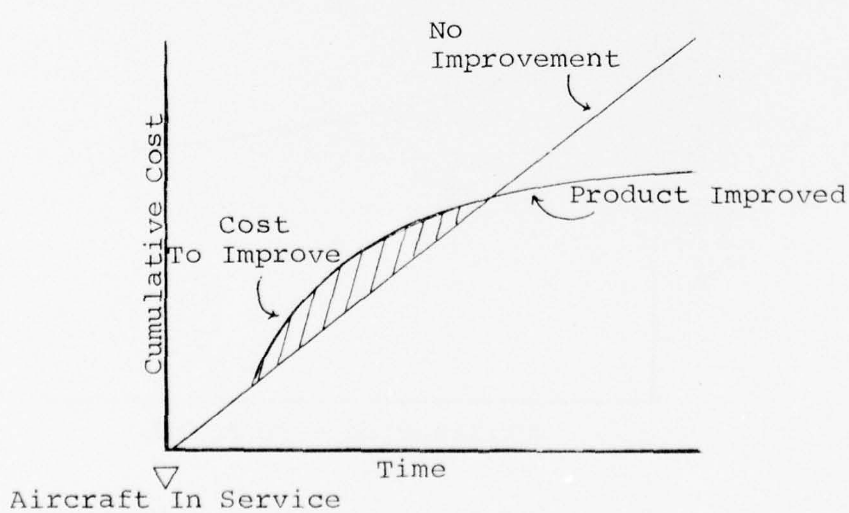

Figure 4. Product Improvement Process

Costs are constant until it is decided to improve the product, at which time they increase. This increase continues until fleet incorporation begins when some payoff starts to show by way of lower operating costs. This is where the curve begins to bend over in Figure 4. As more of the fleet is retrofitted, the savings are increased. The curve eventually intersects the constant cost line of the "no improvement" case. At this point the cumulative costs of both programs are equal. For the improved part case, this is the break-even point, the point at which investment costs have been recovered through lower operating costs. From here on, the operation of the fleet is at a lower cost than could have been achieved by not making the improvement.

This is how cost effectiveness can be measured. The "no improvement" case that was illustrated was for constant operating costs, but the process shown is even more applicable in the case of increasing costs: the total costs of alternatives can be compared and a break-even point can be calculated. Not shown here, but also possible, is the computation of a rate of return on investment based on total cost savings.

THE PRODUCT IMPROVEMENT PROGRAM EVALUATION TECHNIQUE

The purpose of this section of the report was to introduce the concept of in-service aircraft modification and to show which parameters are important in deciding whether a product improvement will be profitable. Using the procedure described in this report, a potential modification to an aircraft system can be evaluated in two different ways: through changes in operational effectiveness, and by cost analysis. Operational measures of effectiveness include availability, utilization and fleet size, while cost parameters include investment, operational cost, net present worth, rate of return and break-even point. Furthermore, this is achieved within the confines of a task accomplishment structure.

THE PRODUCT IMPROVEMENT PROGRAM EVALUATION COMPUTER PROGRAM

This section of the report describes the logic and flow of the computer program and the assumptions that underlie the major subroutines. Also included are a description of the data requirements, the output statistics, and the analytical capability.

PROGRAM OPERATION

Figure 5 is a top-level flowchart of the first half of the computer program. First, a mission is described in terms of the cargo to be carried and the distance to be travelled. It may be the generalized daily routine mission, or it may be a specialized wartime situation. At any rate, it provides the structure within which changes in operational effectiveness can be analyzed. Second, the aircraft's performance characteristics are described in terms of capacity and cruise speed. The computer then calculates the total number of flight hours needed to perform the mission without regard to the number of actual aircraft required. The flight hours are used later to compute the necessary number of aircraft. Next, the computer program digresses temporarily and accepts the R&M characteristics of the total aircraft. The user hypothesizes a steady-state utilization rate, and using classic queueing theory equations, the program derives the availability level associated with the R&M traits and utilization input. This is done for the baseline configuration, and referring to Figure 5, it can be seen that the process is repeated for the alternate.

However, when the queueing section of the program is used this second time, the availability achieved by the baseline design is held constant, and the computer iterates to solve for utilization for the alternate. Assuming that the alternate configuration either fails less frequently or requires fewer manhours to repair, it should be able to fly more often and therefore have a higher utilization. At this point then, the computer program has two utilization levels, the baseline and the alternate, at the same availability. Dividing flight hours per aircraft (utilization) into total flight hours required to perform the mission (calculated earlier) yields the number of aircraft or the fleet sizes necessary for the two configurations to perform the mission. Repeated use of the queueing routine allows utilization to be held constant and the availability to be recalculated for the alternate. Since it is expected that the R&M characteristics of the alternate are better, the availability of the alternate should be higher than the baseline. Additionally, fleet sizes can be held constant with both availability and utilization being recalculated.

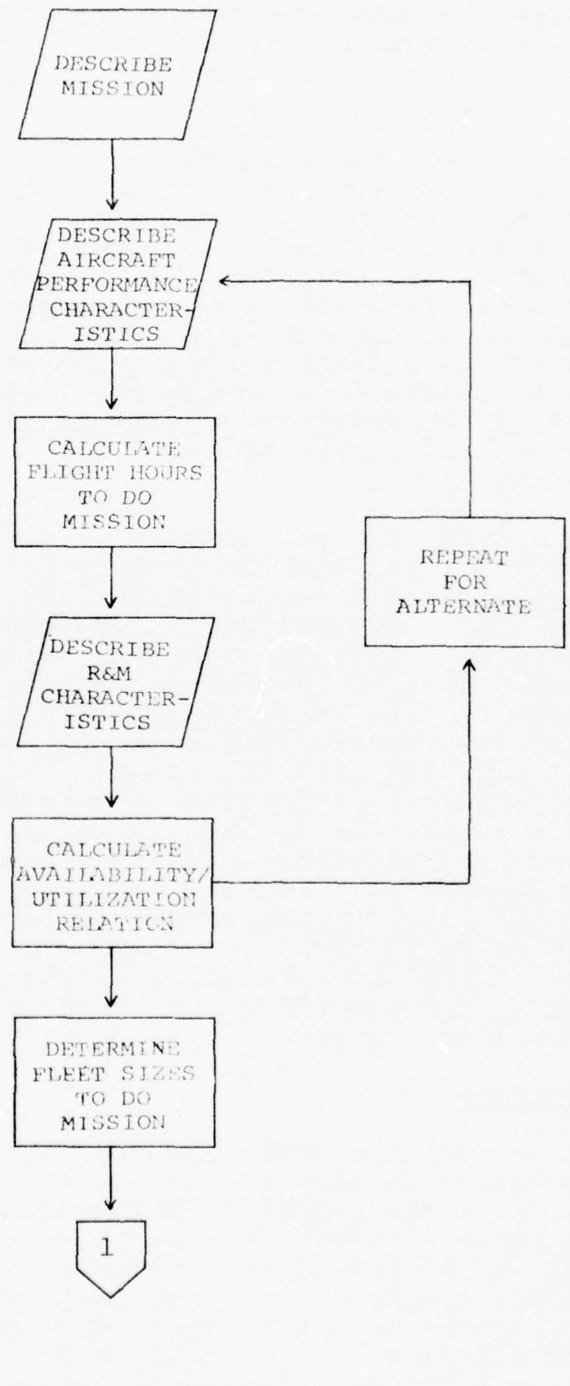

Figure 5. Product Improvement Program Evaluation Top-level Flow Chart - Operational Analysis

Figure 6 is a top-level flow chart of the rest of the program, which develops the cost measures of effectiveness. Operational costs in the framework of this technique are driven by the number of times the component under consideration fails and is repaired or replaced. The number of failures or maintenance manhours is assumed to be reduced by the incorporation of the proposed change into the aircraft. Therefore, the next step is to input the retrofit policy or schedule. The aircraft are then "flown" for the number of months or years under consideration in the study, and the number of failures of the old and new items are computed. In the baseline situation, there is no retrofit policy, and the component is allowed to continue failing at the old rate. Next, costs associated with repair of the old and the new items are input, including the investment required to procure and install the changed part. Costs are accumulated over the specified life cycle, are discounted, and a rate of return and a break-even point are calculated.

At this point then, the two sections of the computer program have provided cost and effectiveness criteria for comparing one possible alternative with the baseline configuration. The user may then vary his input to discover under what conditions the alternate can be made more attractive. Perhaps he should accelerate the incorporation rate or change the design to make it more reliable or easier to repair. The computer program is executed again, and the next set of results are compared with the previous output. This illustrates one use of the technique, to find the best set of circumstances under which a change may be cost and operationally effective. Another use of the procedure is to rate competing product improvement candidates. Each one is optimized separately against the baseline, then a comparison of the proposals can be conducted using the measures of effectiveness output from the program. Since portions of the output are by year over the life cycle, the program manager's funding constraints can also be taken into account.

DATA REQUIREMENTS

In order to develop the data required for the technique described here, it is essential that the user understand the basic assumptions inherent to the process. We are talking primarily about a situation where a number of existing aircraft are fielded and operational, and an R&M-affecting change is suggested for one of the aircraft's components. Two questions need to be answered: how will the change impact operational capability and what will the net cost benefits be. Within that scenario, it is possible to hypothesize a second situation where new aircraft deliveries are still being made or, at the extreme, where no deliveries have been made at the time of analysis but the aircraft has been

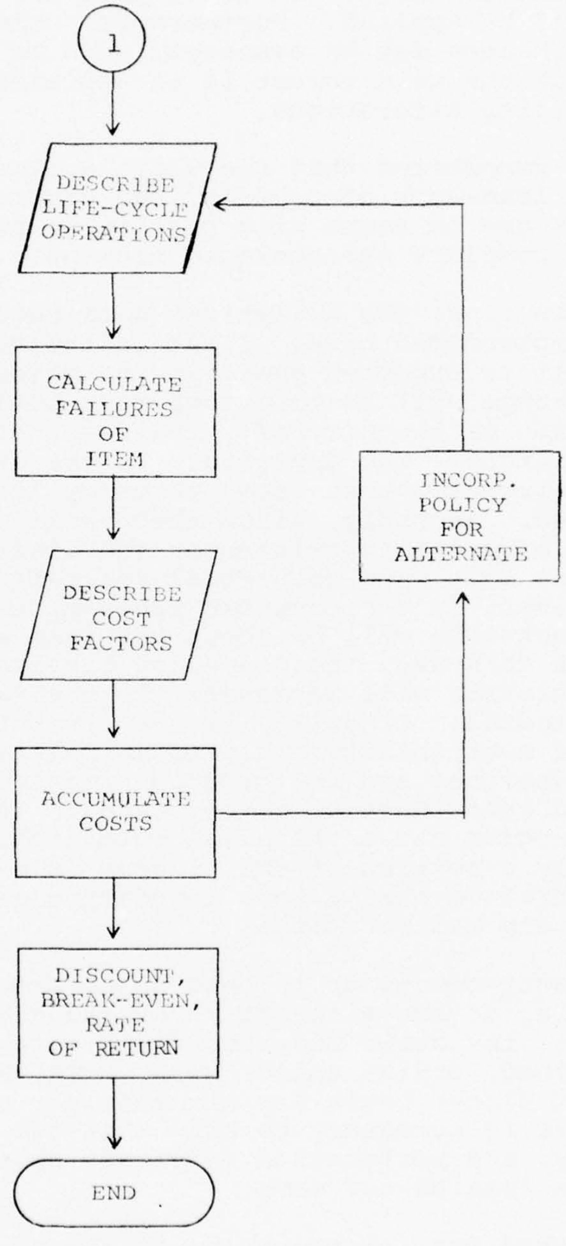

Figure 6. Product Improvement Program Evaluation
Top-level Flow Chart - Cost Analysis

developed. This third application was not the main purpose for which the technique was developed, but in most instances it can still be applied. Furthermore, other performance-impacting changes may be assessed, such as increased speed or payload, but the main thrust is in appraising reliability and maintainability alterations.

It must be remembered that the whole evaluation takes place within the framework of a predefined aircraft role. Therefore, the results are in terms of a particular configuration's ability to complete its assigned mission.

With this in mind, the analytical data requisites will be generally introduced here. First is the task to be accomplished. It is expected that, in the majority of uses, the proposed change will be to a component utilized in the life cycle mission of the aircraft, that is, the application for which the aircraft was designed. If the analysis concerns a transport aircraft, then cargo or troop lift missions should be described. Secondly, since there will usually already be a fleet of aircraft in existence, the mission should be described so that when the actual aircraft performance capability is input to the computer program, the resultant calculated fleet size will be about the same as that which truly exists. In this way, the so-called baseline configuration output statistics will represent the real-world situation that is being studied. Likewise, if the aircraft system has an established availability/utilization relationship, the inputs should be designed and the program executed such that the established relationship is reproduced. In this regard the computer program has a "baseline establishment run" feature, whereby only a portion of the program is executed, until the user is satisfied that a good foundation exists against which to compare any modifications.

The data requirements up to this point are founded on a good understanding of the aircraft under study and its past experience: the basic mission, fleet size, number of seats, useful payload, cruise speed, MTBF, MTTR, NORS, NORM, availability and flight hours per aircraft per month. For the alternate it is necessary to know what the reliability, maintainability, and performance (payload, speed) effects will be; the mission remains the same.

Next, a method for incorporating this improvement into the aircraft must be devised. The information needed here is not as rigid since the user may wish to vary the implementation scheme to determine the most cost-effective schedule. The options available to the user are to have the change put in as the aircraft are being delivered, if new deliveries are still being made, or to have the modifications installed in the field. If installations are made in the field, they may be made at the organizational level or delayed until the aircraft arrive at depot level for repair or overhaul. Since the computer program accepts a certain quantity per month as input for field installation, the user must know or be able to estimate the rate at which aircraft arrive at the depot level if this is the policy to be followed. Through the use of this implementation philosophy and the components' failure rates, the number of old and new item failures are computed. Following this, the operational costs can be calculated. To do this, the average parts and labor costs associated with the old and new item must be supplied for three levels of repair. Other costs are built into the program but can be changed at the user's discretion. Finally, the user must be aware of the investment required to bring about the change. This includes R&D, investment nonrecurring and investment recurring costs. This is where the costs of the modification kits, if that is the procedure, are tallied. If the user cannot estimate investment costs at this time, the program will do it for him based on operational costs and their relationship to total life cycle costs. This illustrates another use of the model: in addition to being able to examine the cost and effectiveness of a particular program given that all the costs and benefits are known, the technique can also be used to determine what funds will have to be spent to get a certain rate of return given that the user only knows what the R&M improvements are and not the cost. This can be done by parametric variation and repeated runs of the program. Since the program execution time is on the order of 5 to 30 seconds depending on the computer used, this is a relatively inexpensive process.

Table 1 contains a summary of the input data required for the computer program. The input category is listed along with a description and a notation as to whether the information is needed separately for the baseline and alternate configurations, or generally for application to both cases.

PROGRAM OUTPUT

Actual reproductions of computer output are not shown here but are fully illustrated in the appendix. However, specific items of output are summarized in a later section of this report where test cases are discussed. The purpose of the program output section is to describe the output statistics that are available to the program user.

TABLE 1. COMPUTER PROGRAM INPUT SUMMARY		
Category	Description	Requirement
Mission Description	Passengers and cargo to be carried and distance to be travelled.	General
Aircraft Performance Characteristics	Payload, cruise speed, number of seats.	Baseline/Alternate
Aircraft R&M Characteristics	Mean time between maintenance, mean time to repair.	Baseline/Alternate
Component R&M Characteristics	Maintenance action rates and manhours.	Baseline/Alternate
Retrofit Policy	Incorporation technique and schedule.	Alternate
Costs	Operations and support	Baseline/Alternate
	Investment	Alternate

The initial portions of output from the computer program concern the operational measures of effectiveness. The total flight hours required to perform the mission are presented for both the baseline and the alternate configurations. If the proposed R&M change will impact the cruise speed or the payload capacity of the alternate, then the alternate will require more or fewer flight hours to perform the mission. Next, holding availability constant, the number of flight hours per aircraft per month that can be achieved by each configuration are shown. Related statistics, such as total down time and total time spent waiting for men, are also computed. Finally, based on the flight hours needed to complete the mission and the utilization capability of the aircraft, the required fleet sizes for the two configurations are calculated for a constant availability level. The program also displays availability and fleet size for a constant utilization, and availability and utilization for a constant fleet size. In summary then, the measures of effectiveness at this point are the total flight hours required to perform the mission, availability and utilization, and the fleet sizes for both the baseline and alternate aircraft. It should be stated here that such operational parameters are rarely sufficient to justify a product improvement program. However, in a situation where a number of projects have equal merit from a cost viewpoint, yet where only a few can be funded, these parameters can be used to decide which ones should be chosen. Obviously, the fact that the alternate configuration might be able to perform the mission with fewer aircraft does not mean that the Army will return these extra aircraft to the contractor. Nevertheless it does provide a measure of effectiveness.

The program next goes through a month by month process of accumulating hours on the parts, having them fail, and getting them repaired. In the alternate case, incorporations of the new part are made according to the schedule. The result is the number of maintenance actions on the old and new items at the three levels of repair for the baseline and alternate cases. These are then costed out in the next subroutine. Additional output includes the number of spares required to support the described operating level and the number of aircraft lost due to attrition. In the event that a program is underway in which new aircraft are purchased to replace those attrited, this number can be compared to the two fleet sizes generated earlier to see how many fewer aircraft need to be replaced in the alternate case. Although attrited aircraft are seldom replaced during peacetime, the output statistics are there for each user's particular application. Likewise, a reduction in the number of spares required may be of little value if a fleet of components and spares has already been purchased and there is no provision for returning the spares to the contractor. Since policies regarding spares and the replacement of aircraft can vary with each application, these two parameters do not enter into the costing subroutine.

The number of maintenance actions on the old and new items at the three maintenance levels are carried over into the next subroutine for the baseline and alternate cases to calculate the costs associated with these repairs. The output shows the life cycle costs of operating the component in the baseline configuration according to the categories described in

AR37-18.[2] Following this, the yearly cash flow is shown, which includes the annual costs, the cumulative costs, and the discounted costs for both cases. The break-even point is displayed, and to demonstrate the effect of the incorporation schedule, the fleet composition of old and new parts and the resultant operating costs are shown by year. Finally, based on the present value of the life cycle cash flow, a true rate of return on the investment is computed.

ANALYTICAL CAPABILITY

As was stated previously, the computer program described in this report represents a technique for examining the cost and operational effectiveness of a proposed aircraft improvement. In a more universal sense, it is a tool that can be used to solve for an optimum life cycle cost-effective R&M level. Figure 7 illustrates the classic economic principle of the marginal rate of return. It is the relationship between the marginal increment of input to output.

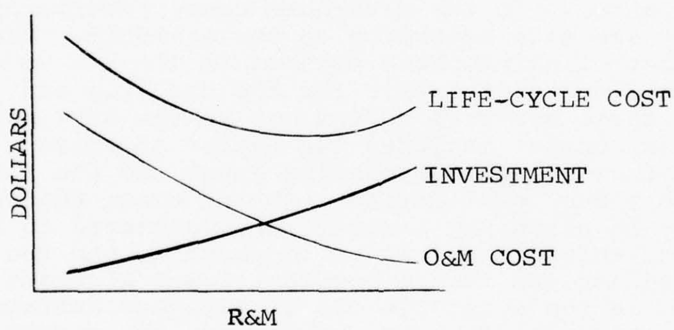

Figure 7. Cost Effective R&M

The top curve, which is the total life cycle cost, is merely the sum of the investment and O&M costs. It is reasoned that higher investment is required to achieve better levels of R&M, and improved R&M results in lower operating cost. However, according to the law of diminishing returns, higher levels of R&M become increasingly more expensive to achieve, until eventually there is no life cycle cost benefit, and in most cases, life cycle costs will increase. In the case of product

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[2]Army Regulation Number 37-18, WEAPON/SUPPORT SYSTEMS COST CATEGORIES AND ELEMENTS, Headquarters Department of the Army, Washington, D.C., October 1971.

improvement programs, better R&M levels can be achieved by investing more money in the design or testing of potential candidates or, after the improvement is designed, by accelerating its incorporation into the fleet. In other words, it may cost more to get the new component into the fleet quickly, but the benefits of the improvement begin sooner.

Parametric Analysis

By varying certain of the computer program inputs, the user can decide either the best way to implement a particular product improvement or choose among competing candidates. Obviously, the first set of parameters to be changed are the MTBFs at the three maintenance levels and the MTTRs. Altering these inputs will change the availability/utilization relationships and possibly fleet size for analyzing operational effectiveness, and will change the number of maintenance actions performed and manhours for examining cost impact. The user should have some idea of what investment costs are necessary to change R&M, but the program will estimate investment costs if they are unknown.

The second major area for parametric analysis is in the incorporation philosophy. The modification schedule is of prime importance, since no benefit can be achieved until the modifications have been made to the aircraft. The sooner the new parts are installed, the sooner the overall R&M level will improve. Naturally, it is expected that quicker kit production and installation will cost more. The concept is illustrated in Figure 8.

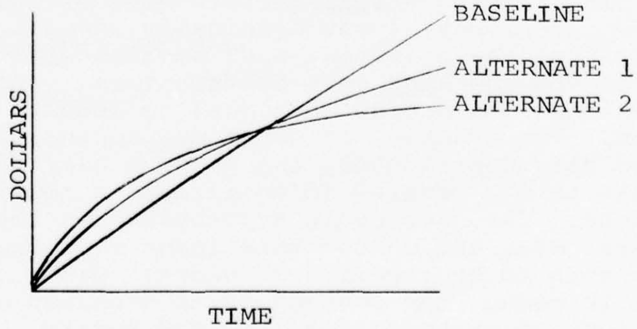

Figure 8. Cumulative Cost of Alternate Incorporation Schedules

One curve shows the cum cost of continuing to operate the baseline configuration. The other two curves show the cost of changing the aircraft. Both of these are lower than the baseline and are viable programs; however, they differ in their change incorporation procedure. Alternate 1 would install the change at overhaul; Alternate 2 would send kits out to the field for immediate implementation. Although Alternate 2 costs more than Alternate 1 in the early stages of the program, in the long run it is less expensive. It could be that funds are not available in the early part of the program, but this is an example of the kind of analysis which can be done by varying the schedule of change incorporation.

These two items, R&M and modification incorporation schedule, are the two main areas for sensitivity analysis, but there are also many minor changes that can be examined in the cost input sections. Perhaps a new manufacturing technique or new materials can be used to lower the value of parts consumed at the depot level. This can be checked for its cost benefit by changing the appropriate input card. Likewise, maybe a less skilled (and less expensive) mechanic can perform the repair. To analyze this, merely change the labor rate. In any case, the model is flexible enough to examine almost any cost-reducing or operations-improving change.

Cost Analysis

One of the most useful areas of the cost output is in the operating cost section. If a particular product improvement is not yielding a satisfactory rate of return or is not saving as much money as was originally thought, a simple examination of the operating cost section will show which categories are the high cost contributors. The user can then backtrack and decide what must be done to remedy the situation. For example, if depot maintenance was found to be a high cost contributor, the program user could change the inputs to the program in an effort to lower depot maintenance costs. The user could hypothesize an improvement in depot level MTBR and change this input to reduce the number of components to be repaired at depot. Other options available are to reduce the cost of parts consumed at depot, reduce the maintenance manhours required for repair, or lower the cost of people working on the component at that level. Any or all of these would result in a decrease in depot maintenance costs.

The cash flow output by year has many applications. For example, the annual costs of competing projects can be plotted, along with budget constraints, as an aid in deciding which can be satisfactorily funded. This concept is illustrated in Figure 9.

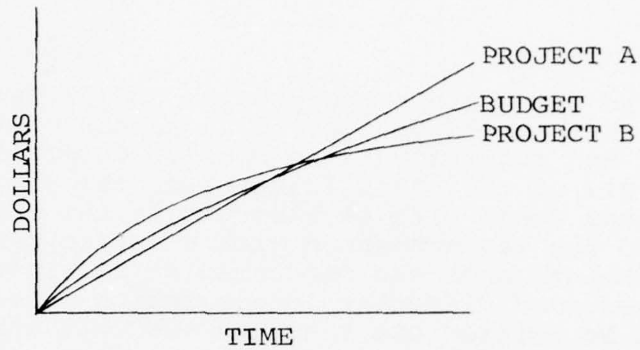

Figure 9. **Alternate Project Cash Flows**

The output can also be used to show the break-even point, which is the year in which all the investment costs have been recovered in reduced operating costs. This point will be different when discounting has been applied, due to the reduction in value of future cash flows to their present value. Since product improvement programs require investment capital in the early years of program life and since discounting factors in the early project years are higher than in later years, discounting will generally push the break-even point out further than when using actual cash flow. Nevertheless, discounting is the recommended DOD procedure.

Another figure of merit from this section of output is the true rate of return on investment. This figure is most relevant when available funds for investment are constrained. In this situation, the program manager wants to know how he can best invest his money, and this is the appropriate statistic. However, in the situation where available money is relatively unlimited or within a limited range, the difference in life cycle cost between baseline and alternate must be considered. For example, two competing projects may have rates of return of 10% and 20%. The logical choice would seem to be the latter. However, this could be a relatively minor aircraft modification, simple to design and install (keeping investment cost low), and having a relatively small total cost benefit but a high rate of return. The first project could represent the solution to a major aircraft problem. It may have high investment costs, causing the project to have a lower rate of return, but have significantly higher total cost savings than the other candidate. If the manager is not limited in his budget and could afford the investment for either one, then he should consider the one with the lower rate of return.

TEST CASES

In order to demonstrate the program and illustrate some of the ways that it can be applied, a number of test cases were developed and run through the model. Generally, these cases utilized all of the major features of the program. Two of the cases dealt with an aircraft in the inventory, the CH-47, and one was concerned with a development aircraft, the UH-61A. Maintenance was performed at all levels, fleet sizes were varied, and different incorporation schedules were tested. It should be pointed out that R&M and cost input data used in the test cases was based on best estimates of the engineers and other personnel involved. As such, the results shown in this section should not be construed as the absolute indication of the effectiveness of the product improvements discussed. The purpose of the test cases was to demonstrate the program, and a true product improvement evaluation would require a more rigorous definition of input prior to execution of the program.

CH-47 Rainshield Stiffener

The Chinook rainshield is mounted on the rotor shaft under the rotor head, and its purpose is to cover and protect the rotor controls, actuators and swashplate assemblies. It provides an aerodynamic flow and keeps rain from entering the aircraft interior. A few years ago, an ECP (Engineering Change Proposal) was submitted to correct a recurring fatigue problem, which manifested itself in the form of cracks in the rainshield stiffener, an integral part of the rainshield. To reduce fatigue failure the proposed new stiffener was the same as the old one except that material would be shotpeened stainless steel instead of the original ALCLAD (aluminum). The standard repair of cracks in the stiffener was to rivet a patch over the cracked area. Although this was simple and inexpensive, it resulted in a lot of down time and consumption of maintenance manhours, since the task required removal of the rotor head. Removal of the Chinook rotor head was estimated to consume about 8.5 maintenance manhours.

The first step in the product improvement analysis was to establish a baseline against which to compare the proposed change. The modification was to be considered only for the CH-47C model aircraft; therefore historical data on this model was examined to determine the appropriate operational parameters. Aircraft mean time between maintenance (MTBM) for all causes was .7505 hour and mean time to repair (MTTR) was 2.15 hours. A representative sample of Vietnam field experience revealed an availability level of about 74% at

50 hours per aircraft per month utilization. Using the MTBM, MTTR and utilization described above as input, varying the crew size eventually yielded an availability level of 73.5%. This was considered to be an acceptable baseline. The organizational level mean time between failures for the rainshield stiffener was expected to improve from 206 hours to 293 hours. This resulted in a change in aircraft MTBM to .7513 hours and a change in MTTR to 2.05 hours. Holding availability constant at the baseline level yielded a new utilization capability of 53 hours per aircraft per month. These figures can be seen in Table 2. A monthly mission

TABLE 2. CH-47 RAINSHIELD STIFFENER

	Baseline	Alternate
Component MTBF Hours	206	293
Component MTBR - AVIM	-	-
Component MTBR - Depot	-	-
Aircraft MTBM Hours	.7505	.7513
Aircraft MTTR Hours	2.15	2.05
Availability	73.5%	73.5%
Utilization	50.0	53.0
Flight Hours Required to do Mission	9849	9853
Fleet Size to do Mission	197	186
Total O&M Cost	$662163	$500558
O&M Cost Savings	-	161605
Cost to Improve (Investment)	-	90990
Net Cost Saving	-	70615
True Rate of Return	-	.81%
Break-Even Point	-	12 Years

was defined such that when the flight hours required to do the mission (9849) were divided by the baseline utilization (50), the resultant baseline fleet size would be the same as the number of aircraft in the inventory, about 197. Since the new rainshield stiffeners increased aircraft weight by 7 pounds, payload was reduced by that much, therefore requiring a few more flight hours to perform the mission (9853). When this was divided by the new utilization (53) the fleet size necessary to perform the mission in the alternate configuration was reduced to 186 aircraft. This was the operational measure of effectiveness: the capability of performing the same mission in the same time frame with 11 fewer aircraft.

The second half of the process was to evaluate the cost effectiveness of the change. For both the baseline and alternate cases, a 15-year life cycle was assumed. During this time utilization was 10 hours per aircraft per month, except for 2 periods of 3 years and 2 years respectively, when a surge situation of 50 hours per aircraft per month was hypothesized. Maintenance manhours per repair was 8.9, and material consumed was valued at $5.00 per repair. Finally, it was assumed that at the start of the analysis there were 148 aircraft in the fleet with 100 more to be delivered at the rate of 2 per month. Upon running the program, there were 7781 repairs of the old rainshield stiffener over 15 years at a total O&M (operations and maintenance) cost in excess of $600,000, as shown in Table 2.

In the alternate case, it was assumed that new stiffeners would be available at the beginning of the second year, that new aircraft delivered would have the new stiffener, and that the rest of the aircraft in the field would be retrofitted at a rate of 18 per month. For the 15 year period, there were 5882 repairs of old and new stiffeners at a total O&M cost of about $500,000. Table 2 shows that the O&M cost savings minus the investment costs yielded a net cost savings of $70,605. It took 12 years for investment costs to be recovered, and the true rate of return was .81%. The true rate of return is based on the present value of the cash flow over the life cycle and is calculated using the following equation:[3]

$$TRR(\%) = \frac{PVB-PVA}{I} \times \frac{100}{N}$$

where PVB = total present value of cash flow for the baseline
PVA = total present value of cash flow for the alternate
I = total investment (discounted)
N = project life

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[3] Rose, J., ECONOMIC ANALYSIS FOR RELIABILITY AND MAINTAINABILITY TRADES, The Boeing Commercial Airplane Company, Seattle, Washington, Boeing Document D6-22972 TN-1, May 1975.

This is an annual rate, and since the discount rate used was 10%, the true rate of return represents a return over and above the 10%.

This process yielded the second half of the output, the cost measure of effectiveness. It should be remembered that, although the program is run from start to finish as a single entity, the two parts are distinct. The fact that operations could be conducted using 11 fewer aircraft did not cause 11 fewer aircraft to be retrofitted. Furthermore, the operational analysis was done at the higher, wartime utilization of 50 hours, while the costs were computed for a peacetime/wartime scenario. No sensitivity analysis was performed in this test case, but one will be shown in the next one.

CH-47 Fuel Pods

A recent field survey revealed a low MTBF and a low MTBR to scrap for the Chinook fuel pods. The skin of the present configuration's fuel pods is a thin aluminum sandwich which is subject to damage in the maintenance and operational environment. Cracks and punctures develop in the skin, in which moisture accumulates causing corrosion and voids between the metal layers. Although many of the repairs can be made on the aircraft, a large number of pods are removed for repair and have to be scrapped. The proposed remedy for the problem consists of replacing the old pods with new ones of composite construction with a nomex core, which would eliminate corrosion. The new pods would also have a high degree of resistance to the type of damage previoulsy experienced. In addition, it is estimated that the new pods could be acquired at about 85% of the cost of the old ones.

A test case was set up and run through the computer program. The results revealed a net saving of $2.8 million over the 20-year life cycle. However, before the run was made, it was intuitively felt that the benefit would be higher than that. It was decided to run the program again with a different incorporation schedule. The first time through, the entire fleet (361 aircraft) was retrofitted at a rate of 3 aircraft or 18 pods per month. This required the acquisition of 361 sets of fuel pods. In the second case, it was assumed that the new pods would be installed only when the old ones were removed and scrapped, a rate of about 9 pods per month. This required the acquisition of only 184 sets. Table 3 shows the results of the second run.

TABLE 3. CH-47 FUEL PODS		
	Baseline	Alternate
Component MTBF Hours	50	400
Component MTBR - AVIM	-	-
Component MTBR - Depot (scrap rate)	1975	*
Aircraft MTBM Hours	.7505	.7605
Aircraft MTTR Hours	2.15	2.13
Availability	73.5%	73.5%
Utilization	50.0	51.3
Flight Hours Required to do Mission	18055	18055
Fleet Size to do Mission	361	352
Total O&M	$35.7M	$2.2M
O&M Cost Savings	-	33.5M
Cost to Improve (Investment)	-	13.8M
Net Cost Saving	-	19.7
True Rate of Return	-	7.1%
Break-Even Point	-	8 Years

*Estimated at 100,000 hours, but for program purposes it was assumed it would not be scrapped.

The change in organizational level MTBF from 50 hours to 400 hours improved the aircraft MTBM from .7505 hours to .7605 hours. At 73.5% availability, the alternate configuration achieved 51.3 flight hours per aircraft per month as compared to the 50 hours per month achieved by the baseline. The fleet sizes required to perform the mission were 361 aircraft for the baseline and 352 aircraft for the alternate. Total O&M cost of the baseline was $35.7 million and included the replacement of over 2,000 spare pods. For the alternate, O&M costs were $2.2 million; however an additional $13.8 million was spent to develop ($.5 million) and acquire the new pods. In the alternate scenario, 1,104 old pods were replaced by new ones. The net cost saving over the life cycle was $19.7 million, the true rate of return was 7.1%, and the break-even point was 8 years.

This case illustrated how sensitivity analyses can be performed using the program. With the fuel pods, due to the nature of the scrap rate it was more profitable to wait for the old pods to be scrapped, than to retrofit the fleet. In other cases or circumstances it could be more effective to install the changed part at a rapid rate. It should be remembered that the purpose of the fuel pod example was to demonstrate the computer program, not to advocate a product improvement program. Data used in the example was based on the best estimates available at the time.

UH-61 FM Homing

This test case shows how the model can be used for analyses concerning aircraft that have been developed but have not yet gone into production. In the UTTAS aircraft, both the pilot and copilot radios had FM homing capability. The radios shared a single antenna by way of two coaxial relays and related wiring. A design-to-cost analysis was performed, and it was decided to take away the FM homing capability of one radio by eliminating the coaxial relay setup and tieing the other radio directly into the antenna. Using data generated from this analysis, a product improvement computer run was made. The results of this run are shown in Table 4.

A new mission was developed to represent the UTTAS operating scenario of 69 hours per aircraft per month. As can be seen from the Table, with an MTBM of 1.9 hours and an MTTR of .85 hour, an availability level of 85.9% was achieved. This included a constant NORS (not operationally ready-supply) rate of 10%, whereas the Chinook runs used 7%. Considering the utilization capability and the flight hours required to perform the mission, a fleet of 1,107 aircraft was needed, thereby representing the true UTTAS procurement planning. Based on the radio system's reliability parameters and repair costs, O&M costs for the 20-year life cycle were $14.2 million. Eliminating the second radio's FM homing capability decreased the frequency of repair at all three maintenance levels. The change from an organizational level MTBF of 94 hours to 134 hours caused an increase in utilization capability of about .4 hour per aircraft per month. This resulted in a reduction in fleet size required to perform the mission to 1,100 aircraft. It is obvious that this measure of effectiveness has greater value in the preproduction phase of the procurement process. O&M costs were reduced by $4.5 million to $9.7 million. Since the change in the system was to be made prior to production and no kits or retrofitting were involved, investment costs were minimal, at $1,862, mostly for drawing changes. Because investment was so low, the net cost saving, the rate of return and the break-even point are not even shown here.

TABLE 4. UH-61 FM HOMING		
	Baseline	Alternate
Component MTBF Hours	94	134
Component MTBR - AVIM	99	145
Component MTBR - Depot	2000	2900
Aircraft MTBM Hours	1.900	1.912
Aircraft MTTR Hours	.850	.850
Availability	85.9%	85.9%
Utilization	69.00	69.42
Flight Hours Required to do Mission	76391	76391
Fleet Size to do Mission	1107	1100
Total O&M Cost	$14.2M	$9.7M
O&M Cost Savings	-	4.5M
Cost to Improve (Investment)	-	1862
Net Cost Saving	-	-
True Rate of Return	-	-
Break-Even Point	-	-

It was intuitively obvious that this case would be a cost effective change, but the operational benefits were not as apparent prior to running the program. In addition, it shows another side of the model. In this situation, the entire aircraft delivery process was simulated in order to calculate the number of expected failures over the life cycle.

Earlier in this report, several areas were noted as likely candidates for sensitivity analyses. These were: the R&M inputs, the product improvement incorporation schedule, and parameters from the O&M cost output. An additional area is the aircraft utilization level. Use of the model revealed that what may be a cost and operationally effective product improvement at 50 hours per aircraft per month, may have little or no payoff at 10 or 20 hours per month. Successive runs of the model can enable the user to determine the aircraft usage level at which a change is profitable. Finally, in the past certain ratios of cost savings to investment have been used by program managers as a criteria for approval of product improvement programs. Ratios of 4 or 6 to 1 have been mentioned. It is felt that this criteria was used in response to a general lack of confidence in cost estimates used as justification for PIP's. However, using the technique described in this report, such high ratios should no longer be required. Since the calculation of the true rate of return takes into account a discount rate of 10%, anytime a PIP analysis results in a positive rate of return, it represents a higher rate of return on investment than that which could be had by not making the change. This is not to say that every PIP in this category should be accepted, since there are cases of high technical risk, but the technique presented in this report does represent a more rigorous approach than that which was used in the past.

CONCLUSIONS

This report introduced a new, integrated technique for evaluating potential aircraft modifications. The approach is the execution of a computer program that measures the cost and operational effectiveness of reliability and maintainability improvements within a task accomplishment structure. It can be effectively used in three ways. First, it can be employed to evaluate the profitability of a product improvement. Second, it can be used to optimize a candidate product improvement program. This can be achieved by varying the R&M improvement level, varying the incorporation policy and schedule, and analyzing the O&M cost output. Finally, the technique can be used to help choose among competing product improvement programs, by comparing their respective cost and operational measures of effectiveness.

The model is not confined to the applications discussed in the report but is limited only by the particular application of the user and his experience with the program. Although the model had not been widely used at the time of the writing of this report, it is felt that little or no changes to the program will be required; nevertheless, it was designed to be quickly and easily modified should additional capabilities be desired.

RECOMMENDATIONS

Based on the results of this study, it is recommended that the technique described in this report be used by program managers and product improvement analysts in the evaluation of R&M affecting product improvements. The technique represents an approach more rigorous than some that have been used in the past and will enable PIP decision-making to be more accurate than previously possible.

It is further recommended that additional work be considered in the evaluation of other areas of product improvement, such as performance, safety and increased mission capability. Finally, a feedback process should be initiated involving the users of the model to ensure that the requirements of the users are being met, and to identify any areas of desired additional capability.

APPENDIX A

PROGRAM DOCUMENTATION

This section of the report provides computer program documentation for the Product Improvement Program Evaluation (PIPE) model described earlier. It includes a description of the problem and method of solution; a list of equations used; definition of input and output; and listings of the source deck, sample input, and output results from the sample input.

DESCRIPTION OF THE PROBLEM

A technique was required which could evaluate the cost and operational effectiveness of planned aircraft modifications. The proposed changes to be examined were of the type which affect reliability and maintainability. The analysis was to be performed in the context of a pre-defined mission, with operational measures of effectiveness included in the output. The program was also to consider means of incorporating the change into the aircraft fleet, and allow cost analysis among the various cost categories. The complexities involved in the calculation of availability through the use of queueing equations, plus the iterative process needed to compute yearly costs, made a computer program the logical method for solving the problem.

METHOD OF SOLUTION

The computer program which was developed compares a baseline configuration with an alternate. It consists of a main program and four major subroutines. Each configuration goes through all four subroutines, and the main program uses results from these to calculate certain measures of effectiveness. The first subroutine, MISHIN, determines how many flight hours would be required for each configuration to complete the described mission. Subroutine QUEUE computes availability/utilization relationships for the baseline and alternate, and the main program combines the results of these first two subroutines to develop the fleet size required by each configuration to perform the mission. The third subroutine, INCORP, accepts the incorporation schedule for the changed component and models the use of the item throughout its life cycle. In the case of the baseline no retrofit schedule is used, and the program flies the components without change. Based on the number of items which fail in this subroutine, the last subroutine, ZCOST, calculates the costs of repairing and replacing the components in both cases. Finally, the main program computes the breakeven point and the true rate of return on investment.

EQUATIONS USED IN THE PROGRAM

Number of passenger sorties, based on the described mission.

$$\text{Passenger Sorties} = \text{Total Passengers} \div \text{Aircraft Passenger Capacity}$$

MISHIN 1

Excess capacity available for cargo after passengers are on board.

$$\text{Excess Capacity} = \text{Aircraft Payload} - (\text{Aircraft Passenger Capacity} * 240)$$

MISHIN 2

Number of cargo sorties based on the described mission.

$$\text{Cargo Sorties} = \left(\text{Total Cargo} - \left(\text{Passenger Sorties} * \text{Excess Capacity} \right) \right) \div \text{Payload}$$

If less than zero, gets set equal to zero.

MISHIN 3

Total number of sorties to be flown based on the described mission.

$$\text{Total Sorties} = \text{Passenger Sorties} + \text{Cargo Sorties}$$

MISHIN 4

Sortie length (flight hours) based on the described mission.

$$\text{Sortie Length} = \left(\begin{matrix}\text{Mission} \\ \text{Distance}\end{matrix} \div \begin{matrix}\text{Aircraft} \\ \text{Speed}\end{matrix} \right) + \text{Hover Time}$$

When hover time is not used, this value is represented as transition time or take-off time.

MISHIN 5

Total number of flight hours required to perform the described mission.

$$\text{Flight Hours} = \text{Total Sorties} * \text{Sortie Length}$$

MISHIN 6

Probability that there are no maintenance actions in the system at a particular time.

$$Po = \frac{1}{\left(\sum_{k=0}^{n-1} (1/k!)(\lambda/\mu)^k \right) + (1/n!)(\lambda/\mu)^n n\mu/(n\mu - \lambda)}$$

where,

λ = 1/MTBM

μ = 1/MTTR

n = number of crews

QUEUE 1

Expected number of maintenance actions waiting for manpower (on the average).

$$\text{MA's Waiting} = \frac{\lambda\mu(\lambda/\mu)^n Po}{(n-1)!(n\mu-\lambda)^2}$$

QUEUE 2

Expected number of maintenance actions in the system (on the average).

$$\text{MA's Total} = \frac{\lambda\mu(\lambda/\mu)^n Po}{(n-1)!(n\mu-\lambda)^2} + \frac{\lambda}{\mu}$$

QUEUE 3

Expected waiting time of a maintenance action.

$$\text{Waiting Time} = \frac{\mu(\lambda/\mu)^n Po}{(n-1)!(n\mu-\lambda)^2}$$

QUEUE 4

Expected total time a maintenance action spends in the system.

$$\text{Total Time} = \frac{\mu(\lambda/\mu)^n Po}{(n-1)!(n\mu-\lambda)^2} + \frac{1}{\mu}$$

QUEUE 5

Cumulative number of maintenance actions for a company of aircraft for one month.

MA's Cum = (Utilization * Number of Aircraft) ÷ MTBM

QUEUE 6

Cumulative waiting time of maintenance actions for a company of aircraft for one month.

Cum Waiting Time = MA's Cum * Waiting Time

QUEUE 7

Total Not Operationally Ready-Maintenance (NORM) time for a company of aircraft for one month.

Total NORM Time = MA's Cum * Total Time

QUEUE 8

Total aircraft calendar hours in a 28-day month.

Aircraft Calendar Time = Number of Aircraft * 24 * 28

QUEUE 9

Percentage of monthly calendar time spent awaiting maintenance.

$$\text{NORM \% Waiting} = \left(\begin{array}{c}\text{Cum Waiting}\\ \text{Time}\end{array} \div \begin{array}{c}\text{Aircraft}\\ \text{Calendar Time}\end{array}\right) * 100$$

QUEUE 10

Percentage of monthly calendar time spent down for maintenance (includes NORM % Waiting).

$$\text{NORM \% Total} = \left(\begin{array}{c}\text{Total NORM}\\ \text{Time}\end{array} \div \begin{array}{c}\text{Aircraft}\\ \text{Calendar Time}\end{array}\right) * 100$$

QUEUE 11

Percentage of monthly calendar time that the aircraft are not down for maintenance, and are available for use.

Availability % = 100 - (NORM % Total + NORS %)

NORS % is an input.

QUEUE 12

Fleet size required to perform the described mission.

Fleet Size = Flight Hours ÷ Utilization

Utilization is an input for the baseline and yields an availability %. For the alternate, the program tries different utilizations until the baseline availability is achieved.

MAIN 1

Operating hours per year compiled on the subject components.

$$\text{Operating Hours (I)} = \text{Number of Components} \;*\; \text{Utilization} \;*\; 12$$

where,

I is the year of the life cycle (up to 20).

INCORP 1

Total number of maintenance actions performed on the subject components by year, by maintenance level over the life cycle.

$$\text{Life Cycle MA's (I, J)} = \text{Operating Hours (I)} \div \text{MTBX (J)}$$

where,

J is the maintenance level (up to 3).

INCORP 2

Cumulative operating hours compiled on the subject components.

$$\text{Cum Flight Hours} = \sum_{I=1}^{Y} \text{Operating Hours (I)}$$

where,

Y is the last year of the life cycle.

INCORP 3

Number of initial spares required at each location.

$$\text{Initial Spares} = \left(\begin{array}{c}\text{Desired Number}\\ \text{Months Supply}\\ \text{on Hand}\end{array} + \begin{array}{c}\text{Number Months}\\ \text{in Pipeline}\end{array}\right) *$$

$$\text{Utilization} * \begin{array}{c}\text{Number of Components}\\ \text{Operating At}\\ \text{Each Location}\end{array} \div \text{MTBR}$$

INCORP 4

Number of components scrapped (replacement spares).

$$\begin{array}{c}\text{Replacement}\\ \text{Spares}\end{array} = \begin{array}{c}\text{Cum Flight}\\ \text{Hours}\end{array} * \text{Scrap Rate}$$

INCORP 5

Total number of maintenance actions performed on the subject components by maintenance level.

$$\text{Sum of MA's (J)} = \sum_{I=1}^{Y} \sum_{J=1}^{3} \text{Life Cycle MA's (I,J)}$$

INCORP 6

Number of depot level maintenance actions performed by contractor.

$$\text{Contractor Overhauls} = \text{Sum of MA's (3)} \star \text{\% Depot Maintenance Performed By Contractor}$$

where,

Sum of MA's (3) is the total number of depot level maintenance actions.

ZCOST 1

Total contractor shipping weight for items repaired by contractor at depot level.

$$\text{Contractor Shipping Weight} = \text{Contractor Overhauls} \star \text{Component Weight} \star 2$$

ZCOST 2

Multiplier to burden contractor costs to include overhead, general and administrative (G&A) and profit.

$$\text{Burden} = 1 + \text{Overhead Rate} + \text{G\&A Rate} + \text{Profit Rate}$$

ZCOST 3

Total cost for contractor transportation of components to and from depot repair facility.

$$\text{Contractor Transportation} = \text{Contractor Shipping Weight} \star \text{Shipping Rate} \star \text{Burden}$$

ZCOST 4

Total cost for depot level maintenance performed by the contractor.

$$\text{Contractor Depot Maintenance} = \text{Contractor Overhauls} * \text{Maintenance Manhours} * \text{Labor Rate} * \text{Parts Cost(3)} * \text{Burden}$$

ZCOST 5

Total contract costs for transportation and depot maintenance.

$$\text{Contract} = \text{Contractor Transportation} + \text{Contractor Overhaul Cost}$$

ZCOST 6

Total In-House (government) cost for parts consumed in the repair of components at the organizational and intermediate levels.

$$\text{Parts} = \sum_{J=1}^{2} \text{Sum of MA's (J)} * \text{Parts Cost (J)}$$

where,

Sum of MA's (1) represents organization level and
Sum of MA's (2) represents intermediate level.

ZCOST 7

Cost of fuel consumed in the operation of the components.

$$\text{POL} = \text{Cum Flight Hours} * \text{SFC} * \text{Fuel Cost}$$

where,

SFC = specific fuel consumption rate

ZCOST 8

Total consumption costs.

$$\text{Consumption} = \text{Parts} + \text{POL}$$

ZCOST 9

Total cost of maintenance labor to repair components at organizational and intermediate levels.

$$\begin{matrix}\text{Maintenance}\\ \text{Labor}\end{matrix} = \sum_{J=1}^{2} \text{Sum of MA's (J)} * \begin{matrix}\text{Maintenance}\\ \text{Manhours (J)}\end{matrix} * \begin{matrix}\text{Labor}\\ \text{Rate (J)}\end{matrix}$$

ZCOST 10

Number of depot level maintenance actions performed in-house.

$$\begin{matrix}\text{In-House}\\ \text{Overhauls}\end{matrix} = \text{Sum of MA's (3)} - \begin{matrix}\text{Contractor}\\ \text{Overhauls}\end{matrix}$$

ZCOST 11

Total in-house shipping weight for items repaired by the government at depot level.

$$\begin{matrix}\text{In-House}\\ \text{Shipping Weight}\end{matrix} = \begin{matrix}\text{In-House}\\ \text{Overhauls}\end{matrix} * \begin{matrix}\text{Component}\\ \text{Weight}\end{matrix} * 2$$

ZCOST 12

Total cost for in-house transportation of components to and from depot repair facility.

In-House Transportation = In-House Shipping Weight * Shipping Rate

ZCOST 13

Total cost for depot level maintenance performed by the government.

In-House Depot Maintenance = In-House Overhauls * Maintenance Manhours (3) *

Labor Rate (3) * Parts Cost (3)

ZCOST 14

Total in-house costs for operations and maintenance (O&M).

In-House = Maintenance Labor + Consumption + In-House Transportation

In-House Depot Maintenance + Program Management Costs

ZCOST 15

Total operations and maintenance costs for both in-house and contract costs.

Operating Costs = Contract + In-House

ZCOST 16

Total life cycle cash flow attributable to the subject component.

$$\begin{array}{c} \text{Cumulative} \\ \text{Cash Flow} \\ \text{Actual} \end{array} = \begin{array}{c} \text{Operating} \\ \text{Costs} \end{array} + \begin{array}{c} \text{R\&D} \\ \text{Costs} \end{array} + \begin{array}{c} \text{Investment} \\ \text{Recurring} \end{array} + \begin{array}{c} \text{Investment} \\ \text{Nonrecurring} \end{array}$$

ZCOST 17

Discounted value of total life cycle cash flow.

$$\begin{array}{c} \text{Present Value} \\ \text{of Cash Flow} \end{array} = \sum_{I=1}^{Y} \text{Cash Flow }(I) * (1 + i)^{-(I-.5)}$$

where,

I is the year
i is the discount rate

Cash Flow (I) is calculated by year using the ZCOST equations shown in this section.

ZCOST 18

Investment costs for alternate component configuration.

$$\text{Investment} = \begin{array}{c} \text{R\&D} \\ \text{Costs} \end{array} + \begin{array}{c} \text{Investment} \\ \text{Recurring} \end{array} + \begin{array}{c} \text{Investment} \\ \text{Nonrecurring} \end{array}$$

These costs are discounted using equation ZCOST 18.

ZCOST 19

True rate of return on investment.

$$\text{True Rate of Return} = \left(\begin{array}{l} \text{Baseline} \\ \text{Discounted} \\ \text{Cash Flow} \end{array} - \begin{array}{l} \text{Alternate} \\ \text{Discounted} \\ \text{Cash Flow} \end{array} \right) \div \text{Investment} * \frac{100}{N}$$

where,

N is the project life.

MAIN 2

DEFINITIONS OF INPUT DATA

ILT	mission leg type
INLEGS	number of legs
ILGDIS	leg distance in kilometers
IMD	mission duration in hours (used instead of ILGDIS)
IMISND	mission number
IMTYP	mission type
INPAS	number of passengers
INLIT	number of litters
INCAR	cargo weight
ICLS	aircraft mission class
IMLOAD	indivisible load weight if load cannot be broken down into smaller pieces
LASTCD	tells the program whether or not this is the last card in the mission description (yes or no; 1 or 0)
LSCASE	tells the program whether or not this is the last case to be run (yes or no; 1 or 0)
IHTMI	hover time with internal load in minutes
IHTMX	hover time with external load in minutes
IMCLSS	aircraft mission class
NAME	aircraft name
ISEAT	number of passenger seats in the aircraft
LITTER	number of litters which the aircraft can carry
IAMBS	number of ambulatory or attendant seats in the litter configuration
KMPHI	cruise speed with internal load in kilometers per hour
KMPHX	cruise speed with external load in kilometers per hour

IPAY	payload in pounds
IFA	floor area in square feet
NX	number of maintenance crews at the organizational level
XTBF	total aircraft mean time between maintenance including scheduled and unscheduled maintenance
TIMEX	total aircraft mean time to repair
TUIL	monthly aircraft utilization
AC	number of aircraft per company
ZZNORS	not-operationally-ready-supply (NORS) percent
IBER	tells the program whether or not this is a baseline establishment run (yes or no; 1 or 0)
LR	tells the program whether or not this is the last baseline establishment run (yes or no; 1 or 0)
MONTHS	number of months being considered in project study
NACSTR	number of components in the fleet at the beginning of the study period
NDLVCD	if aircraft are still being delivered with this component on, this tells the program whether they are being delivered at an irregular rate (yes or no; 1 or 0)
MODLV	if aircraft are still being delivered with this component on, and the delivery rate is constant, this is the number of components per month
MOS	the number of months that deliveries will continue
NDLWMD	tells the program whether the aircraft are being delivered with the modified part (yes or no; 1 or 0)
MOSTRT	start month for aircraft that are being delivered with the modification
NFHCD	tells the program whether the components are operating at an irregular utilization rate (yes or no; 1 or 0)
MOFH	flight hours per component per month, if utilization is constant

MODTT4	total number of aircraft delivered with the modified part
OLRATE	subscripted variable which gives the MTBF, MTBR to AVIM and MTBR to depot for the old component configuration
EWRATE	subscripted variable which gives the MTBF, MTBR to AVIM and MTBR to depot for the new component configuration
NAME	component configuration name
INSCD1	if the new component is to be installed in the field (or at depot), tells the program whether they are being incorporated at an irregular rate
LEVEL1	if the incorporation rate is constant, number of modified parts incorporated per month
MEVEL1	if the incorporation rate is irregular, number of months that incorporations continue
MODTT1	total number of field incorporations
MMSTRT	start month for field incorporations
LOCAL	regarding the initial inventory level, the number of months' of spares that are kept on hand at each location
LINPIP	regarding the initial inventory level, the pipeline length for turnaround of spares
NCOMP	the number of aircraft company locations
ACATR	component attrition (scrap) rate per 100,000 hours
MOAC	subscripted variable (240), which tells the program how many components are being delivered per month, when aircraft are being delivered at an irregular rate
MOUTIL	subscripted variable (240), which tells the program the utilization per component per month, when utilization is irregular
INC1	subscripted variable (240), which tells the program how many field incorporations per month take place, when the incorporation rate is irregular

The following six input definitions apply to both the old item and the new item; the first variable name pertains to the old item and the second pertains to the new item.

NDL, NDLN	the percent of depot level maintenance performed by the contractor
CRATE, CRATEN	contractor unburdened hourly rate (dollars per hour)
HMM, HMMN	subscripted variable (3) which gives average maintenance manhours to repair the component at organizational, intermediate and depot
PARTS, PARTSN	subscripted variable (3) which gives average value of parts consumed per repair of the component at the three repair levels
POLRA, POLRAN	pounds of fuel consumed per operating hour; this should only be used if the change in the component will change the fuel consumption rate, otherwise leave blank
LBSO, LBSN	component shipping weight
NOCPM	subscripted variable (20) for yearly cost of program management
OHD	contractor overhead percent
GNA	contractor general and administrative percent
PROFIT	contractor profit percent
XPORTC	contractor shipping rate (dollars per 100 lb)
XPORTI	in-house shipping rate (dollars per 100 lb)
CJP	cost per gallon for fuel (JP-4)
FI	discount rate (%)

The following input definitions describe the subscripted variable OUT. This variable name is used for all of the Army Regulation 37-18 cost categories.

OUT (1)	total research and development (R&D) costs
OUT (3)	R&D engineering costs
OUT (4)	R&D tooling costs

OUT (5)	R&D prototype production
OUT (6)	any other R&D costs not itemized
OUT (7)	R&D general and administrative costs
OUT (8)	R&D profit
OUT (9)	quantity of prototypes
OUT (11)	in-house R&D program management costs
OUT (14)	total investment nonrecurring costs
OUT (16)	investment nonrecurring advanced production engineering costs
OUT (17)	investment nonrecurring tooling costs
OUT (18)	investment nonrecurring manufacturing costs
OUT (19)	investment nonrecurring quality control costs
OUT (20)	any other investment nonrecurring costs not itemized
OUT (21)	investment nonrecurring general and administrative costs
OUT (22)	investment nonrecurring profit
OUT (24)	investment nonrecurring in-house program management costs
OUT (27)	total investment recurring costs
OUT (29)	investment recurring engineering costs
OUT (30)	investment recurring tooling costs
OUT (31)	investment recurring quality control costs
OUT (32)	investment recurring manufacturing costs
OUT (33)	investment recurring first destination transportation costs
OUT (34)	any other investment recurring costs not itemized
OUT (35)	investment recurring general and administrative costs

OUT (36)	investment recurring profit
OUT (38)	in-house transportation costs
OUT (39)	in-house program management costs
OUT (40)	quantity of components produced
NCODE	tells the program whether overhead is included in the cost (yes or no; 1 or 0)
NRDEST	tells the program whether to estimate R&D costs (yes or no; 1 or 0)
NRD	subscripted variable (5) for yearly cost of R&D
NINEST	tells the program whether to estimate investment nonrecurring costs (yes or no; 1 or 0)
NIN	subscripted variable (20) for yearly investment nonrecurring costs
NUNITC	number of units to be shipped by contractor; use only if first destination transportation costs are unknown
LBSC	shipping weight of component for contractor shipping cost calculation
NUNITI	number of units to be shipped by government; use only if in-house transportation costs are unknown
LBSI	shipping weight of component for in-house shipping cost calculation
NIREST	tells the program whether to estimate investment recurring costs (yes or no; 1 or 0)
NIR	subscripted variable (20) for yearly investment recurring costs
NAME	subscripted variable (57, 8) which gives labels to the cost categories

DEFINITIONS OF OUTPUT DATA

ISOR	number of sorties required to complete a particular mission
FLTHL	number of flight hours for each sortie
ISORT	total number of sorties required for all missions
TFLT	total number of flight hours required for all missions
MTL	maximum number of seats utilized when aircraft is payload constrained
MLL	maximum number of litters utilized when aircraft is payload contrained
MAS	maximum number of ambulatory seats utilized when aircraft is payload constrained
IDIV	number of missions that should be deleted on the basis of the indivisable load being greater than the payload capability
MNUM	mission number to be deleted
LSIZ	load weight to be deleted
TILU	flight hours per aircraft per month (utilization)
XREORD	mean time to repair (MTTR)
XXQ	expected queue length
XXWAIT	expected waiting time for men
XXNUM	expected number of tasks in the system
XXTIME	expected time in the system
XZ	probability of no tasks in the system
XTWTIM	total waiting time
XTDTIM	total not-operationally-ready-maintenance (NORM) time
XONORW	NORM percent-waiting
XONORT	NORM percent-total

AVAIL	availability percent
TUIL	utilization when utilization is so high that it results in a constant queue
TFLT1	baseline flight hours required to perfrom the mission
TFLT2	alternate flight hours required to perform the mission
AVAIL1	baseline availability percent
AVAIL2	alternate availability percent
UTIL1	baseline utilization
UTIL2	alternate utilization, holding availability constant
FLTSZ1	baseline fleet size required to perform the mission
FLTSZ2	alternate fleet size required to perform the mission, holding availability constant
ZVAIL2	alternate availability percent, holding utilization constant
ZUTIL2	alternate utilization
FLTSZ4	alternate fleet size, holding utilization constant
AVAIL3	alternate availability percent, holding fleet size constant
UTIL3	alternate utilization, holding fleet size constant
NOLTOT	subscripted variable (3) which gives number of maintenance actions on the old item at the three repair levels
NEWTOT	subscripted variable (3) which gives number of maintenance actions on the new item at the three repair levels
LOCMFH	total operating hours accumulated on the old items over the life cycle
NWCMFH	total operating hours accumulated on the new items over the life cycle

NSPARS	initial spares required per location
NACATR	parts scrapped over the life cycle
OUT	subscripted variable (60) which gives total costs by category for the baseline
OUTA	subscripted variable (60) which gives total costs by category for the alternate
COST	double subscripted variable (20, 3) which gives costs by year by category (annual cost, cumulative cost, present value) for the baseline
COSTA	double subscripted variable (20, 3) which gives costs by year by category (annual cost, cumulative cost, present value) for the alternate
IBRKEV	symbol to designate in which year the break-even point is reached, when costs are not discounted
IBRDIS	symbol to designate in which year the break-even point is reached, when costs are discounted
OM	subscripted variable (20) which gives annual operations and maintenance (O&M) costs for the alternate
TEMP	cumulative O&M costs for the alternate
NOLD	subscripted variable (20) which gives number of old items in the fleet by year
NNEW	subscripted variable (20) which gives number of new items in the fleet by year
NUMTOT	total number of components, both old and new in the fleet
VEST	total investment, discounted
TRR	true rate of return on investment

INPUT DATA

The following section shows the input data as it was coded on the forms for the sample test case.

Run no.

Page of

MISSION DATA

Card A

1. Leg type *1 1 (col. 1)	2. Number of legs 1 (col. 2)	3. Leg distance (km) 255 (cols. 3–5)
3. Mission duration 0.0 (cols. 6–8)	5. Mission number 1 (col. 9)	6. Mission type *5 6 (col. 10)
7. Number of passengers 212872 (cols. 11–16)	8. Number of litters 0 (cols. 17–21)	9. Cargo weight 65022720 (cols. 22–29)
10. Aircraft mission Class *2 1 (col. 30)	11. Indivisible load weight 1 (cols. 31–35)	12. Last card in mission description? * 3 1 (col. 36)
		13. Last case? * 4 1 (col. 37)

*1 Leg types - 1 = round trip, carries load out returns empty.
2 = one way

*2 Mission class - 3 = medevac, 1 = all others

*3 When only one card describes the mission, should have a 1 (yes); when using more than one card, last card should have a 1.

*4 1 = yes.

*5

MISSION TYPE	DESCRIPTION
1	Passengers
2	Passengers
3	Litter Tasks
4	Cargo (internal)
5	Cargo (external)
6	Passengers and internal cargo
7	Passengers and external cargo
8	Observation or attack
9	Move to position

Run no.
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Card B

AIRCRAFT CAPABILITY (BASELINE)

1. Hover time with internal load (min.) 2 (cols 1–3)	2. Hover time with external load (min.) 2 (cols 4–6)	3. Mission class *1 1 (cols 7–9)
4. Aircraft name 47C BASELINE (cols 10–18)	5. Number of seats 44 (cols 22–24)	6. Number of litters 24 (cols 25–27)
7. No. of ambulatory seats *2 2 (cols 28–30)	8. Cruise speed with internal load (kmph) 259 (cols 31–33)	9. Cruise speed with external load (kmph) 238 (cols 34–36)
10. Payload (pounds) 24000 (cols 37–41)	11. Floor area (square feet) *3 240 (cols 42–46)	

*1 Mission class - 3 = medevac, 1 = all others; this must agree with mission class in block 9 of mission data card in order for this aircraft to fly that mission.

*2 Seats in addition to litters on medevac flights.

*3 Used for killed in action (KIA) evacuation. 1 KIA = 10 sq. ft.

Run no.

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RAM DATA
(BASELINE)

Card C

1. Number of crews 6 (column 1)	2. Aircraft MTBF 0.7505 (columns 3–11)
3. Aircraft average MTTR 2.15 (columns 12–17)	4. Monthly aircraft utilization 50.0 (columns 18–22)

5. Number of aircraft per company 16. (columns 23–27)	6. NORS level 7.0 (columns 28–31)	7. Baseline establishment run? *1 0 (column 32)
		8. Last baseline establishment run? *2 (column 33)

*1 1 = yes; if yes, run will terminate after giving availability/utilization output.

*2 1 = yes; if no, additional 'c' cards may follow.

			Run no. Page of
Card D	AIRCRAFT CAPABILITY (ALTERNATE)		
1. Hover time with internal load (min.) 2 (cols 1–3)	2. Hover time with external load (min.) 2 (cols 4–6)	3. Mission class *1 1 (cols 7–9)	
4. Aircraft name 47 ALTERNATE (cols 10–18)	5. Number of seats 44 (cols 22–24)	6. Number of litters 24 (cols 25–27)	
7. No. of ambulatory seats *2 2 (cols 28–30)	8. Cruise speed with internal load (kmph) 259 (cols 31–33)	9. Cruise speed with external load (kmph) 238 (cols 34–36)	
10. Payload (pounds) 23993 (cols 37–41)		11. Floor area (square feet) *3 240 (cols 42–46)	

*1 Mission class - 3 = medevac, 1 = all others; this must agree with mission class in block 9 of mission data card in order for this aircraft to fly that mission.

*2 Seats in addition to litters on medevac flights.

*3 Used for killed in action (KIA) evacuation. 1 KIA = 10 sq. ft.

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Card E

RAM DATA
(ALTERNATE)

1. Number of crews 6 (col. 1)	2. Aircraft MTBF 0.7513 (cols. 3–11)	
3. Aircraft average MTTR 2.05 (cols. 12–17)	4. Monthly aircraft utilization . (cols. 18–22)	
5. Number of aircraft per company 16. (cols. 23–27)	6. NORS level 7.0 (cols. 28–31)	

Run no.

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Card F

INCORPORATION DATA
(BASELINE)

1. Number of months in study 180 (col. 1–3)	2. Number of components in fleet 296 (col. 4–7)	3. If AC still being delivered, irregular delivery rate? *1 0 (col. 8)
4. If constant delivery rate, no. components per mo. 4 (col. 9)	5. Number of months 25 (col. 11–13)	6. AC delivered with modification? *2 0 (col. 14)
7. Start month for deliveries *3 1 (col. 15–17)	8. Irregular utilization? *1 0 (col. 18)	9. If constant utilization, flight hours/component/month 50 (col. 19–21)

10. Total no. mods to be installed on new aircraft as delivered.
0 (col. 22–25)

11.

	Old item	New item
MTBF	206.0 (col. 26–32)	292.7 (col. 33–39)
MTBR to AVIM	. (col. 40–46)	. (col. 47–53)
MTBR to depot	. (col. 54–60)	. (col. 61–67)

12. Configuration name
OLD STIFFNER (col. 68–79)

*1 1 = yes; if yes, irregular rate and/or utilization can be entered on special succeeding cards.

*2 1 = yes

*3 with reference to block 1, no. months in study

Run no.
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FIELD INCORPORATION
(BASELINE)

Card G

1. Irregular field mod incorporation rate? *1 — 0 (col. 1)	2. If constant, no. incorporated per mo. — 0 (cols. 2–4)	3. If irregular, number of months — 0 (cols. 5–7)
4. Total field incorporations — 0 (cols. 8–11)	5. Start month *2 — 0 (cols. 12–14)	
6. Spares stocking level: 1 month's quantity on hand, or ___ months (col. 15); 4 months pipeline quantity, or ___ months (col. 17)		7. Comp. attrition rate 2 per 100,000 hrs, or ___ /100,000 (cols. 19–24)
*1 1 = yes; if yes, irregular rate can be entered on special succeeding cards. *2 With reference to block 1 of incorporation data card (previous card).		8. No. of company locations. ___ (col. 25)

Card H (optional)

DELIVERIES, FLIGHT HOURS, OR

INCORPORATIONS PER MONTH
(BASELINE)

Run no.

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(NOT REQUIRED THIS RUN)

01 02 03	04 05 06	07 08 09	10 11 12	13 14 15	16 17 18	19 20 21	22 23 24	25 26 27	28 29 30	31 32 33	34 35 36	37 38 39	40 41 42	43 44 45	46 47 48	49 50 51	52 53 54	55 56 57	58 59 60	61 62 63	64 65 66	67 68 69	70 71 72

This card may be used when deliveries, flight hours, and/or incorporations per month occur at an irregular rate.

Each 3-column field represents 1 month. There are 24 fields per line, and 10 lines for a total of 240 months or 20 years.

Run no.

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INCORPORATION DATA
(ALTERNATE)

Card I

1. Number of months in study: 180	2. Number of components in fleet: 296	3. If AC still being delivered, irregular delivery rate? *1: 0
4. If constant delivery rate, no. components per mo.: 4	5. Number of months: 25	6. AC delivered with modification? *2: 1
7. Start month for deliveries *3: 13	8. Irregular utilization? *1: 0	9. If constant utilization, flight hours/component/month: 50

10. Total no. mods to be installed on new aircraft as delivered: 52

11.	Old item	New item
MTBF	206.0	292.7
MTBR to AVIM	.	.
MTBR to depot	.	.

12. Configuration name: NEW STIFFNER

*1 1 = yes; if yes, irregular rate and/or utilization can be entered on special succeeding cards.

*2 1 = yes

*3 with reference to block 1, no. months in study

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FIELD INCORPORATION
(ALTERNATE)

Card J

1. Irregular field mod incorporation rate? *1 0 1	2. If constant, no. incorporated per mo. 3 7 2 4	3. If irregular, number of months 0 5 7
4. Total field incorporations 3 4 4 8 11	5. Start month *2 1 3 12 14	
6. Spares stocking level: 1 month's quantity on hand, or [ ] months (15) 4 months pipeline quantity, or [ ] months (17)	7. Comp. attrition rate 2 per 100,000 hrs, or [.] /100,000 19 24	
*1 1 = yes; if yes, irregular rate can be entered on special succeeding cards. *2 With reference to block 1 of incorporation data card (previous card).	8. No. of company locations. [ ] 25	

Card K (optional)	DELIVERIES, FLIGHT HOURS, OR INCORPORATIONS PER MONTH (ALTERNATE)	Run no. Page of

(NOT REQUIRED THIS RUN)

01 02 03	04 05 06	07 08 09	10 11 12	13 14 15	16 17 18	19 20 21	22 23 24	25 26 27	28 29 30	31 32 33	34 35 36	37 38 39	40 41 42	43 44 45	46 47 48	49 50 51	52 53 54	55 56 57	58 59 60	61 62 63	64 65 66	67 68 69	70 71 72

This card may be used when deliveries, flight hours, and/or incorporations per month occur at an irregular rate.

Each 3-column field represents 1 month. There are 24 fields per line, and 10 lines for a total of 240 months or 20 years.

Run no.

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OPERATING COST DATA
(BASELINE - OLD ITEM)

Card L

1. % of depot level maintenance performed by contractor 0 1 3	2. Contractor unburdened hourly rate 0.00 4 8	3. Avg. MMH to repair at depot level 0.0 9 14
4. Avg. value of parts consumed at depot repair 0.00 15 22	5. Avg. value of parts consumed at AVUM repair 5.00 23 28	6. Avg. MMH to repair at AVUM level 8.9 29 33
7. Lbs. of fuel consumed per flt. hr. *1 0.0 34 39	8. Avg. value of parts consumed at AVIM repair 0.00 39 44	9. Avg. MMH to repair at AVIM level 0.0 45 49
10. Component shipping weight 0 50 52		

*1 Should only be completed if the new item will cause this to change.

		Run no. page of
	OPERATING COST DATA (BASELINE - NEW ITEM)	

Card M

1. % of depot level maintenance performed by contractor [. .] 1 3	2. Contractor unburdened hourly rate [. . . .] 4 8	3. Avg. MMH to repair at depot level [. . . . .] 9 14
4. Avg. value of parts consumed at depot repair [. . . . . . .] 15 22	5. Avg. value of parts consumed at AVUM repair [. . . . .] 23 28	6. Avg. MMH to repair at AVUM level [. . . .] 29 33
7. Lbs. of fuel consumed per flt. hr. *1 [. . . .] 34 38	8. Avg. value of parts consumed at AVIM repair [. . . . .] 39 44	9. Avg. MMH to repair at AVIM level [. . . .] 45 49
10. Component shipping weight [. .] 50 52		

*1 Should only be completed if the new item will cause this to change.

OPERATING COST - PROGRAM MGMT.
(BASELINE)

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Card N

Year	Columns	Year	Columns
1	1 – 8	2	9 – 16
3	17 – 24	4	25 – 32
5	33 – 40	6	41 – 48
7	49 – 56	8	57 – 64
9	65 – 72	10	73 – 80
11	1 – 8	12	9 – 16
13	17 – 24	14	25 – 32
15	33 – 40	16	41 – 48
17	49 – 56	18	57 – 64
19	65 – 72	20	73 – 80

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Card 0

CONSTANT FACTORS (BASELINE)

1. overhead 180% (1–6) general & admin. 17% (7–12) profit 10% (13–18)	2. Contractor shipping rate $17.00 per 100 pounds (19–23)
3. Army labor rates per hr. AVUM $10.00 (24–28) AVIM 11.00 (29–33) depot 13.50 (34–38)	4. In-house shipping rate $13.00 per 100 pounds (39–43)
5. Cost per gallon for fuel (JP-4) $ 0.45 (44–47)	6. Discount rate 10% (48–51)

This card shows values used in the program, which may be changed by the user.

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OPERATING COST DATA
(ALTERNATE - OLD ITEM)

Card P

1. % of depot level maintenance performed by contractor 0 1 3	2. Contractor unburdened hourly rate 0.00 4 8	3. Avg. MMH to repair at depot level 0.0 9 14
4. Avg. value of parts consumed at depot repair 0.00 15 22	5. Avg. value of parts consumed at AVUM repair 5.00 23 28	6. Avg. MMH to repair at AVUM level 8.9 29 33
7. Lbs. of fuel consumed per flt. hr. *1 0.0 34 38	8. Avg. value of parts consumed at AVIM repair 0.00 39 44	9. Avg. MMH to repair at AVIM level 0.0 45 49
10. Component shipping weight 0 50 52		

*1 Should only be completed if the new item will cause this to change.

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OPERATING COST DATA
(ALTERNATE - NEW ITEM)

Card Q

1. % of depot level maintenance performed by contractor 0 1 3	2. Contractor unburdened hourly rate 0.00 4 8	3. Avg. MMH to repair at depot level 0.0 9 14
4. Avg. value of parts consumed at depot repair 0.00 15 22	5. Avg. value of parts consumed at AVUM repair 5.00 23 28	6. Avg. MMH to repair at AVUM level 8.9 29 33
7. Lbs. of fuel consumed per flt. hr. *1 0.0 34 38	8. Avg. value of parts consumed at AVIM repair 0.00 39 44	9. Avg. MMH to repair at AVIM level 0.0 45 49
10. Component shipping weight 0 50 52		

*1 Should only be completed if the new item will cause this to change.

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OPERATING COST - PROGRAM MGMT.
(ALTERNATE)

Card R

Year	Columns	Year	Columns
1	1–8	2	9–16
3	17–24	4	25–32
5	33–40	6	41–48
7	49–56	8	57–64
9	65–72	10	73–80
11	1–8	12	9–16
13	17–24	14	25–32
15	33–40	16	41–48
17	49–56	18	57–64
19	65–72	20	73–80

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Card S

CONSTANT FACTORS
(ALTERNATE)

1.			2. Contractor shipping rate	
overhead	180%	1 – 6		
general & admin.	17%	7 – 12		
profit	10%	13 – 18	$17.00 per 100 pounds	19 – 23

3. Army labor rates per hr.			4. In-house shipping rate	
AVUM	$10.00	24 – 28		
AVIM	11.00	29 – 33		
depot	13.50	34 – 38	$13.00 per 100 pounds	39 – 43

5. Cost per gallon for fuel (JP-4)		6. Discount rate	
$ 0.45	44 – 47	10%	48 – 51

This card shows values used in the program, which may be changed by the user.

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R&D COSTS

Card T

1. Contract — Overhead already included (1 = yes)

	Columns	Overhead already included (1 = yes)
Engineering	1–7	8
Tooling	9–15	16
Prototype prod.	17–23	24
Other	25–30	31
G&A	32–37	
Profit	38–43	
Qty. of prototypes	44–46	
In-house Program mgmt.	47–53	

2. If you do not wish to break out cost elements,

Total R&D costs (54–61)

3. R&D costs are unknown - Estimate (1 = yes) 0 (62)

4. R&D costs per year:

Year	Columns	Year	Columns
1	1–8	4	9–16
2	17–24	5	25–32
3	33–40		

Run no.

Page of

INVESTMENT NONRECURRING COSTS

Card U

1. Contract	Columns	Overhead already included? (1 = yes)
Adv. prod. eng.	1–7	8
Tooling	9–15	16
Manufacturing	17–23	24
Quality Control	25–31	32
Other	33–38	39
G&A	40–45	
Profit	46–51	
In-house Program mgmt.	52–58	

2. If you do not wish to break out cost elements,

Total Inv. Nonrecurring Costs: 16027 (columns 59–66)

3. Inv. nonrecurring costs are unknown - Estimate (1 = yes) (column 67)

Card V

INVESTMENT NONRECURRING COSTS

Run no.

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Year	Columns	Entry	Year	Columns	Entry
1	1–8	1 6 0 2 7	2	9–16	
3	17–24		4	25–32	
5	33–40		6	41–48	
7	49–56		8	57–64	
9	65–72		10	73–80	
11	1–8		12	9–16	
13	17–24		14	25–32	
15	33–40		16	41–48	
17	49–56		18	57–64	
19	65–72		20	73–80	

Run no.

Page of

INVESTMENT RECURRING COSTS

Card W

1. Contract — Overhead already included? (1 = yes)

	Field (columns)	Overhead already included? (column)
Engineering	1–7	8
Tooling	9–15	16
Quality Control	17–23	24
Manufacturing	25–32	33
First dest. transp.	34–40	
Other	41–47	
G&A	53–59	
Profit	63–69	

OR

2. No. of units to be shipped: (48–52)

lbs/unit (60–62)

3. In-house

	Field (columns)
Transportation	1–7
Program mgmt.	8–14

OR

4. No. of units to be shipped: (15–19)

lbs/unit (20–22)

5. If you do not wish to break out elements,

Total Inv.Rec. costs 74963 (23–31)

6. Inv. recurring costs unknown -

Estimate (1 = yes) (32)

7. Qty. of kits or components produced 450 (33–36)

INVESTMENT RECURRING COSTS

Run no.	
Page	of

Card X

Year				Year			
1		1	8	2	2382	9	16
3	72581	17	24	4		25	32
5		33	40	6		41	48
7		49	56	8		57	64
9		65	72	10		73	80
11		1	8	12		9	16
13		17	24	14		25	32
15		33	40	16		41	48
17		49	56	18		57	64
19		65	72	20		73	80

PROGRAM LISTING

```
*JOB            STEVE,KP=29,LINES=60,PAGES=99,TIME=180,RUN=CHECK LIST=NO
      DIMENSION OUT(60),OUTA(60),NUMOL(20,3),NUMEW(20,3),NOLTOT(3),
     1 NEWTOT(3),         NFHYR(20,2),COST(20,3),COSTA(20,3),IBRKEV(20),
     2 IBRDIS(20),NOLD(20),NNEW(20),OM(20),NUMO1(20,3),NAME(57,8),
     3 NUME1(20,3),NOLTO1(3),NEWTO1(3),NFHY1(20,2)
      COMMON ILT(100), INLEGS(100), ILGDIS(100), IMISND(100),
     1                              IMTYP(100), IMD(100), INPAS(100),
     2 INLIT(100), INCAR(100),ICLS(100), IMLOAD(100)
      DATA                IBECUM/'*'/,IBEDIS/'#'/,IBLAN1/' '/
C-----READ LABELS
      DO 5 I=1,57
    5 READ(5,7) (NAME(I,J),J=1,8)
    7 FORMAT(8A4)
C-----READ IN MISSION CARDS
   10 DO 14 I=1,100
      READ(5,15) ILT(I),INLEGS(I),ILGDIS(I),IMD(I),IMISND(I),
     1           IMTYP(I),          INPAS(I),INLIT(I),INCAR(I),
     2  ICLS(I),IMLOAD(I),LASTCD,LSCASE
      NA=I
      IF(LASTCD.EQ.1) GO TO 16
   14 CONTINUE
   15 FORMAT(2I1,I3,F3.1, 2I1,    I6,I5,I8,I1,I5,2I1)
   16 CALL MISHIN(NA,TFLT1)
      NFLAG=0
      CALL QUEUE(UTIL1,TDTIME,AVAIL1,DESNOR,NFLAG,X,Z,DUMMY1,DUMMY2,XYZ)
C     MAIN 1
      FLTSZ1=TFLT1/UTIL1
      CALL MISHIN(NA,TFLT2)
      UTIL3=TFLT2/FLTSZ1
      NFLAG=1
      CALL QUEUE(UTIL2,TDTIME,AVAIL2,DESNOR,NFLAG,ZUTIL2,ZVAIL2,UTIL3,
     1 AVAIL3,XYZ)
      FLTSZ2=TFLT2/UTIL2
      FLTSZ4=TFLT2/ZUTIL2
      WRITE(6,9000) TFLT1,TFLT2,AVAIL1,AVAIL2, UTIL1,UTIL2,
     1 FLTSZ1,FLTSZ2,AVAIL1,ZVAIL2,UTIL1,ZUTIL2,FLTSZ1,FLTSZ4,AVAIL1,
     2 AVAIL3,UTIL1,UTIL3,FLTSZ1,FLTSZ1
C-----FIRST INCORP CALL PROVIDES DATA FOR
C-----FIRST ZCOST CALL. DITTO SECOND CALLS.
      LFLAG=1
      CALL INCORP(MODTT1,MODTT2,MODTT3,MODTT4,NUMO1,NUME1,NOLTO1,
     1 NEWTO1,LOCMF1,NWCMF1,MAC,NFHY1,NYR,NOLD,NNEW,LFLAG)
      LFLAG=2
      CALL INCORP(MODTT1,MODTT2,MODTT3,MODTT4,NUMOL,NUMEW,NOLTOT,
     1 NEWTOT,LOCMFH,NWCMFH,JAC,NFHYR,NYR,NOLD,NNEW,LFLAG)
      JFLAG=0
      CALL ZCOST(NUMO1,NUME1,NOLTO1,NEWTO1,JFLAG,LOCMF1,NWCMF1,OUT,COST,
     1 NFHY1,OM,VEST,NYRCHK,TMP)
      JFLAG=1
      CALL ZCOST(NUMOL,NUMEW,NOLTOT,NEWTOT,JFLAG,LOCMFH,NWCMFH,OUTA,
     1 COSTA,NFHYR,OM,VEST,NYRCHK,TMP)
      OUT(57)=MAC
      OUTA(57)=JAC
      WRITE(6,8449)
      DO 500 I=1,57
      IF(I.EQ.1.OR.I.EQ.14.OR.I.EQ.27.OR.I.EQ.43) GO TO 450
      IF(I.EQ.2.OR.I.EQ.10.OR.I.EQ.15.OR.I.EQ.23.OR.I.EQ.28) GO TO 475
      IF(I.EQ.37.OR.I.EQ.40.OR.I.EQ.44.OR.I.EQ.49.OR.I.EQ.57) GO TO 475
      WRITE(6,8500) (NAME(I,K),K=1,8),OUT(I),OUTA(I)
      GO TO 500
```

```
  450 WRITE(6,8450) (NAME(I,K),K=1,8),OUT(I),OUTA(I)
      GO TO 500
  475 WRITE(6,8475) (NAME(I,K),K=1,8),OUT(I),OUTA(I)
  500 CONTINUE
      WRITE(6,8600)
      ICHCUM=0
      ICHDIS=0
      TEMP=OM(1)
      DO 601 I=1,NYR
      IBRKEV(I)=IBLAN1
      IBRDIS(I)=IBLAN1
      IF(ICHCUM.NE.0) GO TO 580
      IF(COSTA(I,2).GT.COST(I,2)) GO TO 580
      IF(I.GE.NYRCHK) IBRKEV(I)=IBECUM
      ICHCUM=1
  580 IF(ICHDIS.NE.0) GO TO 600
      IF(COSTA(I,3).GT.COST(I,3)) GO TO 600
      IF(I.GE.NYRCHK) IBRDIS(I)=IBEDIS
      ICHDIS=1
  600 IF(I.GT.1) TEMP=TEMP+OM(I)
      NUMTOT=NOLD(I)+NNEW(I)
  601 WRITE(6,8700) I,(COST(I,J),J=1,3),(COSTA(I,J),J=1,2),IBRKEV(I),
     1 COSTA(I,3),IBRDIS(I),OM(I),TEMP,NOLD(I),NNEW(I),NUMTOT
C     MAIN 2
      WRITE(6,8800)
      RETURN=COST(NYR,3)-COSTA(NYR,3)
      TRR=(RETURN/VEST)*(100/NYR)
      WRITE(6,8900) COST(NYR,2),COSTA(NYR,2),COST(NYR,3),COSTA(NYR,3),
     1VEST,TRR
      WRITE(6,9010)
 8000 FORMAT(8A4)
 8449 FORMAT(1H1,T3,'OUTPUTS :',T41,'BASELINE',T64,'ALTERNATE',/)
 8450 FORMAT(T3,8A4,1XF10.0,13XF10.0)
 8475 FORMAT(T3,8A4,7XF10.0,13XF10.0)
 8500 FORMAT(T3,8A4,13XF10.0,13XF10.0)
 8600 FORMAT(1H1,/////T18,'B A S E L I N E',T72,'A L T E R N A T E',
     1 /T12,'ANNUAL        CUM.      PRESENT',
     2  T47,'ANNUAL        CUM.      PRESENT',
     A T85,'ANNUAL       CUM       OLD     NEW    TOTAL',/T3,'YEAR',
     3   T13,'COST         COST       VALUE',
     4   T48,'COST         COST        VALUE'
     B T83,'O&M COSTS   O&M COSTS   ITEMS   ITEMS   ITEMS',/)
 8700 FORMAT(T5,I2,3(1X,F10.0),2X,2(1X,F10.0), 1X,1A1,1X,F10.0,1X,1A1,
     1 2X,    2(1X,F10.0),3(3X,I4))
 8800 FORMAT(          //T3,' * - BREAK EVEN POINT, (COSTS NOT DISCOUNTED)
     1.',/T3,' # - BREAK EVEN POINT, (PRESENT VALUE).',//)
 8900 FORMAT(/////T40,'BASELINE    ALTERNATE',
     1 //T3,'CUMULATIVE CASH FLOW, ACTUAL',T36,2(2XF10.0),
     2 //T3,'PRESENT VALUE OF CASH FLOW  ',T36,2(2XF10.0),
     3 //T3,'INVESTMENT (PRESENT VALUE)',    T50,F10.0,
     4 //T3,'TRUE RATE OF RETURN ON INVESTMENT',T51,F8.2' %'//)
 9000 FORMAT(1H1,///T19,'FLEET SIZING SUMMARY',//
     Z               T37,'BASELINE     ALTERNATE',//T3,'FLT. HRS. REQUIRED
     1',/T3,'TO PERFORM MISSION',T35,2(F10.2,3X),//T3,'HOLDING AVAILABIL
     2ITY CONSTANT :',
     3/T3,'AVAILABILITY %',T39,2(F6.2,7X),/T3,'UTIL. (FH/AC/MO)',T39,
     4 2(F6.2,7X),/T3,'FLEET SIZE (AC)',T38,2(F7.2,6X),
     5 //T3,'HOLDING UTILIZATION CONSTANT :',
     6/T3,'AVAILABILITY %',T39,2(F6.2,7X),/T3,'UTIL. (FH/AC/MO)',T39,
     7 2(F6.2,7X),/T3,'FLEET SIZE (AC)',T38,2(F7.2,6X),
```

```
     8 //T3,'HOLDING FLEET SIZE CONSTANT :',
     9/T3,'AVAILABILITY %',T39,2(F6.2,7X),/T3,'UTIL. (FH/AC/MO)',T39,
     A 2(F6.2,7X),/T3,'FLEET SIZE (AC)',T36,2(F7.2,6X),/)
9010 FORMAT(1H1)
     IF(LSCASE.NE.1) GO TO 10
     STOP
     END
```

```
      SUBROUTINE MISHIN(NA,TFLT)
      DIMENSION IMCLSS(2),NAME(3,03),ISEAT(02),LITTER(02),KMPHI(02),KMPH
     1X(02),IPAY(02),MNUM(20),LSIZ(20),IAMBS(02),IFA(02)
      COMMON ILT(100),INLEGS(100),ILGDIS(100),IMISND(100),
     1                          IMTYP(100),IMD(100),INPAS(100),
     2 INLIT(100),INCAR(100),ICLS(100),IMLOAD(100)
      READ(5,10)                IHTMI,IHTMX,IMCLSS(1),(NAME(1,I),I=1,3),
     1 ISEAT(1),LITTER(1),IAMBS(1),KMPHI(1),KMPHX(1),IPAY(1),IFA(1)
   10 FORMAT(3I3,3A4,5I3,2I5)
      INL=0
      K=1
      IC=0
C  DETERMINE AIRCRAFT CONSTRAINTS  ( IF ANY )
C  MAX TROOPS LIFTED PER SORTIE  ( MTL)
      MTL=IPAY(K)/240
      IF(MTL.LT.ISEAT(K))IC=1
      IF(ISEAT(K).LT.MTL)MTL=ISEAT(K)
C  MAX LITTERS LIFTED PER SORTIES  (MLL )
      MLL=IPAY(K)/240
      IF(MLL.LT.LITTER(K))IC=1
      IF(LITTER(K).LT.MLL)MLL=LITTER(K)
C  AMBULATORY SEATS  (MAS )
      MAS=(IPAY(K)-(MLL*240))/240
      IF(MAS.GT.IAMBS(K))MAS=IAMBS(K)
      KI=1
      I=0
      FLT2CS=0.
      IDIV=0
      ISORT=0
      IDUM=0
C  WRITE AIRCRAFT CHARACTERISTICS
      WRITE(6,100)(NAME(K,J),J=1,3),IMCLSS(KI),      IPAY(K),KMPHI(K),
     1KMPHX(K),IFA(K),ISEAT(K),LITTER(K),IAMBS(K)
      IF(IC.GT.0)WRITE(6,99)MTL,MLL,MAS
      WRITE(6,1101)
      LINES=4
      DO 80 M=1,NA
      IF(ICLS(M).NE.IMCLSS(KI))GO TO 80
      IF(INL.GT.0)GO TO 1
      FLT=0.
      SORTR=0.
      FLTHM=0.
      INL=INLEGS(M)
 1    IF((INPAS(M)+INLIT(M)+INCAR(M)+IMLOAD(M)+IMD(M)).EQ.0)IMTYP(M)=9
      IF(ILT(M).EQ.0)ILT(M)=4
      IF(ILT(M).EQ.9)GO TO 81
      IF(IMLOAD(M).LT.IPAY(K))GO TO 19
      IDIV=IDIV+1
      MNUM(IDIV)=IMISND(M)
      LSIZ(IDIV)=IMLOAD(M)
 19   IGRP=IMCLSS(KI)
      GO TO (25,80,20,25,80),IGRP
C MEDICAL EVACUATION PHASE
C EMPTY LEG
 20   IF((INLIT(M)+INPAS(M)+INCAR(M)).NE.0)GO TO 21
      ISOR=1
      GO TO 50
C LITTERS ONLY
 21   IF((INPAS(M)+INCAR(M)).NE.0)GO TO 22
      ISOR=FLOAT(INLIT(M))/FLOAT(MLL)+.99
```

```
           GO TO 50
      C LITTERS & PASSENGERS
   22      IF(INCAR(M).NE.0)GO TO 23
           ISOR1=INLIT(M)/MLL
           IF(INLIT(M).LT.MLL)ISOR1=1
           ILITL=INLIT(M)-(ISOR1*MLL)
           IF(ILITL.LE.0)ILITL=0
           INPASC=MAS*ISOR1
           INPASL=INPAS(M)-INPASC
           IF(INPASL.LE.0)GO TO 28
           ISOR2=FLOAT(ILITL+INPASL)/FLOAT(MLL+MAS)+.99
           GO TO 26
   28      ISOR2=1
   26      ISOR=ISOR1+ISOR2
           GO TO 50
      C EXTERNAL LOAD
   23      IF(IMLOAD(M).GT.IPAY(K))GO TO 24
           ISOR=FLOAT(INCAR(M))/FLOAT(IPAY(K))+.99
           GO TO 70
   24      ISOR=0
           FLTHL1=0.
           FLTHL2=0.
           GO TO 62
      C
      C EMPTY LEG
   25      IF((IMLOAD(M)+INCAR(M)+INPAS(M)).NE.0)GO TO 27
           ISOR=1
           GO TO 50
      C  KIA   ( 10 SQ. FT. PER MAN)
   27      IF(IMTYP(M).NE.4)GO TO 30
           IF((INCAR(M)/IMLOAD(M)-INCAR(M)/240).NE.0)GO TO 30
           KIA=INCAR(M)/IMLOAD(M)
           KFLA=KIA*10
           ISOR=FLOAT(KFLA)/FLOAT(IFA(K))+.99
           IF(IPAY(K).LT.(240*(IFA(K)/10)))ISOR=FLOAT(KIA*240)/FLOAT(IPAY(K))
          1+.99
           GO TO 50
      C PASSENGERS ONLY
      C    MISHIN 1
   30      IF(INCAR(M).NE.0)GO TO 31
           ISOR=FLOAT(INPAS(M))/FLOAT(MTL)+.99
           GO TO 50
      C CARGO ONLY OR PASSENGERS LESS THAN SEATS AND CARGO
   31      IF(INPAS(M).GT.MTL)GO TO 32
           ISOR=FLOAT( INPAS(M)*240+INCAR(M))/FLOAT(IPAY(K))+.99
           GO TO 50
      C PASSENGER GREATER THAN SEATS & CARGO
      C    MISHIN 2,3,4
   32      ISOR2=0
           ISOR1=INPAS(M)/MTL
           INPASL=INPAS(M)-(ISOR1*MTL)
           INCARN=INCAR(M)-(ISOR1*(IPAY(K)-MTL*240))
           IF(INCARN.LE.0)GO TO 33
           ISOR2=FLOAT(INPASL*240+INCARN)/FLOAT(IPAY(K))+.99
           GO TO 34
   33      IF(INPASL.GT.0)ISOR2=1
   34      ISOR=ISOR1+ISOR2
      C FLIGHT TIME LEG INTERVAL
   50      IF(IMTYP(M).EQ.5)GO TO 70
           IF(IMTYP(M).EQ.7)GO TO 70
```

```
C       MISHIN 5
        FLTHL1=((FLOAT(ILGDIS(M))/FLOAT(KMPHI(K)))*60.+FLOAT(IHTMI))/60.
        FLTHL2=FLOAT(IMD(M))/60.
        KLT=ILT(M)
        GO TO (61,62,62,62),KLT
 61     SORT=FLOAT(ISOR)
        FLTHL=(2.*FLTHL1)+FLTHL2
        GO TO 103
 62     SORT=FLOAT(ISOR)
        FLTHL=FLTHL1+FLTHL2
        IF(INL.LT.INLEGS(M))GO TO 103
        IF((LINES+INLEGS(M)+1).LT.57)GO TO 103
        WRITE(6,1101)
        LINES=4
C PRINT LEG DATA
  103 WRITE(6,1104) IMISND(M),IMTYP(M),IMCLSS(KI),ILT(M),INLEGS(M),
     1 ILGDIS(M), INPAS(M),INLIT(M),INCAR(M),IMLOAD(M),ISOR,FLTHL
        LINES=LINES+1
C FLIGHT TIME MISSION
        IF(SORT.GT. SORTR)SORTR=SORT
        FLTHM=FLTHM+FLTHL
        INL=INL-1
        IF(INL.GT.0)GO TO 80
        GO TO 105
C FLIGHT TIME - LEG EXTERNAL
 70     FLTHL1=(((FLOAT(ILGDIS(M))/FLOAT(KMPHI(K)))*60.)+FLOAT(IHTMI))/60.
        FLTHL2=(((FLOAT(ILGDIS(M))/FLOAT(KMPHX(K)))*60.)+FLOAT(IHTMX))/60.
        FLTHL3=IMD(M)/60.
        KLT=ILT(M)
        GO TO (71,72,72,72),KLT
 71     SORT=FLOAT(ISOR)
        FLTHL=FLTHL1+FLTHL2+FLTHL3
        GO TO 103
 72     SORT=FLOAT(ISOR)
        FLTHL=FLTHL2+FLTHL3
        GO TO 103
C TOTAL FLIGHT TIME BY CLASS
C       MISHIN 6
 105    FLT=FLTHM*SORTR
        LINES=LINES+2
        ISORT=ISORT+SORTR
        IF(IMISND(M).EQ.IDUM)GO TO 79
        I=I+1
        IDUM=IMISND(M)
 79     FLT2CS=FLT2CS+FLT
 80     CONTINUE
C TOTAL FLIGHT TIME
 81     TFLT=FLT2CS
        WRITE(6,1107) ISORT,TFLT
        IF(IDIV.EQ.0)GO TO 90
        WRITE(6,108)IDIV
        DO 109 J1=1,IDIV
 109    WRITE(6,110)MNUM(J1),LSIZ(J1)
 90     CONTINUE
 99     FORMAT(////,T8,'*** PAYLOAD  CONSTRAINED ***'//T10,'MAX SEATS UTIL
       1IZED --',I5/T10,'MAX LITTERS ---------',I5/T10,'AMBULATORY SEATS -
       2---',I5)
 100    FORMAT(1H1,////////,T8,'AIRCRAFT - ',2X,3A4/T8,'CLASS - ',I2,
       1                    ///T8,'PAYLOAD  ---------------',I6,' LBS'/T8,'CRU
       2ISE SPEED (KMPH)'/T12,'INTERNAL  ----------',I5/T12,'EXTERNAL  ---
```

```
     3-------',I5//T8,'CABIN COMPARTMENT'/T10,'FLOOR AREA -----------',
     4I5,' SQ.FT.'/T10,'NUMBER OF SEATS -------',I5/T10,'NUMBER OF LITTER
     5S -----',I5/T12,'AMBULATORY SEATS ---',I5)
 108  FORMAT(T40,I2,' MISSIONS SHOULD BE DELETED ON BASIS OF'/T36,'INDIV
     1ISABLE LOADS GREATER THAN PAYLOAD CAPABILITY')
 110  FORMAT(T43,'MISSION ',I3,10X,'LOAD WT ',I5,' LBS')
 1101 FORMAT(///////T5,'MISSION',T20,'LEG            NUMBER OF    CARGO  I
     ANDV',
     1  /T3,'NO TYPE CLS  TYPE NO DIST    PAX   LITS   POUNDS  LOAD SORT
     2IES   FLT. HRS.',/)
 1104 FORMAT(T2,I3,1XI3,2(2XI3),2XI2,1XI4,2(1XI6),1XI8,1XI5,1XI7,1X,
     1F11.3)
 1107 FORMAT(T58,I7,1X,F11.3)
      RETURN
      END
```

```
232          SUBROUTINE QUEUE(PTILU,TOTIME,PAVAIL,DESNOR,NFLAG,ZTILU,ZAVAIL,
            1 ZUTIL3,ZVAIL3,NXYZ)
       C-----
       C-----EXCESS OF COMMENT/FORTRAN CARDS DUE TO INPUT INSTEAD OF CALCULATED NORS
       C-----
233          DIMENSION ELOW(7),HIGH(7),NHEAD(2,2),NUMS(2,3),
            1 NCREW(2,2), INTVL(2,3), LENGTH(2,2),NUNITS(2,2),
            2         XREORD(2),XXQ(2),XXWAIT(2),XXNUM(2),XXTIME(2),XZ(2),
            3XTWTIM(2),XTDTIM(2),XONORN(2),XONORT(2),NX(2),TIMEX(2),
            4XTBF(2),FA(100)
234          COMMON ILT(100),INLEGS(100),ILGDIS(100),IMISND(100),
            1                             IMTYP(100), IMD(100), INPAS(100),
            2INLIT(100),INCAR(100),ICLS(100),IMLOAD(100)
235          DATA ELOW/1.2,1.1,1.05,1.01,1.001,1.0001,1.00001/,
            1 HIGH/.8,.9,.95,.99,.999,.9999,.99999/, NHEAD/'N O ','N O ',
            2'R M ','R S '/, NUMS/'TO &','NO. ',' E S','SPAR','IZE ','ES  '/,
            3 NCREW/'CREW','    ','S   ','    '/, INTVL/'MTTR','REOR','    ',
            4'DER ','    ','TIME'/, LENGTH/'HOUR','DAYS','S   ','    '/,
            5 NUNITS/'MEN ','SPAR','    ','E   '/
236          REAL NUM,UM,FACTM
237          NZFLAG=0
238          NEWFLG=0
       C  50 READ(5,55)NX(1),XTBF(1),TIMEX(1),TUIL,AC,NX(2),XTBF(2),TIMEX(2)
239       50 READ(5,55)NX(1),XTBF(1),TIMEX(1),TUIL,AC,ZZNORS,IBER,LR
240          IF(NFLAG.EQ.0) NXYZ=TUIL
241          IF(NFLAG.EQ.1) TUIL=NXYZ
       C  55 FORMAT(I2,F9.4,F6.2,F5.1,F5.0,I4,F9.4,F6.2)
242       55 FORMAT(I2,F9.4,F6.2,F5.1,F5.0,F4.1,2I1)
243          TIMEX(1)=1./TIMEX(1)
       C     TIMEX(2)=1./TIMEX(2)
244          NOTFLG=3
       C     IF(NX(1).GE.NX(2)) NKNT=NX(1)
       C     IF(NX(2).GE.NX(1)) NKNT=NX(2)
245          NKNT=NX(1)
246          CALL FACTOR(NKNT,FA)
247          GO TO 70
248       60 TUIL=ZUTIL3
249          NEWFLG=1
250       70 DO 4200 KL=1,2
251          IF(KL.EQ.2) GO TO 4200
252          UTIL=TUIL
253          TIME=TIMEX(KL)
254          IF(KL.EQ.2) TIME=TIMEX(KL)/24.
255          N=NX(KL)
256          TILU=UTIL
257          IF(N.EQ.1) GO TO 1000
258          REORDR=(1./TIME)/24.
259          TBR=1./(672/(AC*UTIL/XTBF(KL)))
260          UTIL=UTIL*AC
261          LINES=0
262          ULAM=TBR/TIME
263          M=N-1
264          SUM=1.+ULAM
265          IF(N.EQ.2) GO TO 110
266          DO 100 I=2,M
267          UM=FA(I)
268          AULAM=ALOG(ULAM)
269          AULAM=AULAM*I
270          DUM=AULAM-UM
271          IF(DUM.GT.174.673) GO TO 115
```

```
      SUMCHK=ALOG(SUM)
      SIZCHK=SUMCHK+DUM
      IF(SIZCHK.GT.174.673) GO TO 115
      DUM=EXP(DUM)
  100 SUM=SUM+DUM
  110 XULAM=ALOG(ULAM)
      XULAM=XULAM*N
      UM=FA(N)
      XNX=N
      XYZ=N*TIME-TBR
C-----POTENTIAL INFINITE QUEUE
      IF(XYZ.GT.0) GO TO 113
      IF(NFLAG.EQ.0) GO TO 5026
      WRITE(6,5100) TUIL
      N1=1000000
      GO TO 4800
  113 TEMP=-UM+      XULAM +ALOG(XNX)+ALOG(TIME)-ALOG((XYZ))
      TEMP=EXP(TEMP)
      Z=1./(SUM+TEMP)
      GO TO 120
  115 Z=0.1E-75
C
C-----CALCULATE REPEATED VALUES
C     QUEUE 1
  120 ULAMN=(ALOG(ULAM))*N
      ULAM2=(N*TIME-TBR)**2
      FACTM=FA(M)
C-----EXPECTED Q LENGTH
C     QUEUE 2
      XQ=ALOG(TBR)+ALOG(TIME)+      ULAMN +ALOG(Z)-FACTM-ALOG(ULAM2)
      XQ=EXP(XQ)
      IF(XQ.LT.0) GO TO 5026
C-----EXPECTED NUMBER OF UNITS IN THE SYSTEM
C     QUEUE 3
      XNUM=XQ+ULAM
C-----EXPECTED WAITING TIME OF AN ARRIVAL
C     QUEUE 4
      XWAIT=ALOG(TIME)+ULAMN+ALOG(Z)-FACTM-ALOG(ULAM2)
      XWAIT=EXP(XWAIT)
C-----EXPECTED TIME AN ARRIVAL SPENDS IN THE SYSTEM
C     QUEUE 5
      XTIME=XWAIT+(1./TIME)
      GO TO 1010
C-----IF N=1
 1000 XQ=(TBR**2)/(TIME*(TIME-TBR))
      XNUM=TBR/(TIME-TBR)
      XWAIT=TBR/(TIME*(TIME-TBR))
      XTIME=TIME/(TIME-TBR)
      Z=1.-(TBR/TIME)
 1010 REORDR=REORDR*24
C     QUEUE 6
      XFAILS=UTIL/XTBF(KL)
C     QUEUE 7
      TWTIME=XWAIT*XFAILS
C     QUEUE 8
      TOTIME=XTIME*XFAILS
      IF(KL.EQ.2) TOTIME=XWAIT*XFAILS
C     QUEUE 9,10,11
      OONORW=TWTIME/(AC*24*28)*100
      OONORT=TOTIME/(AC*24*28)*100
```

```
      TOTAL=Z
      P=TBR/(N*TIME)
      K=N
      G=K*P
      I=1
      PN=G*Z
      TOTAL=TOTAL+PN
      IF(N.EQ.1) GO TO 4100
 4100 CONTINUE
      XREORD(KL)=REORDR
      XXQ(KL)=XQ
      XXWAIT(KL)=XWAIT
      XXNUM(KL)=XNUM
      XXTIME(KL)=XTIME
      IF(KL.EQ.2) XXTIME(KL)=XWAIT
      XZ(KL)=Z
      XTWTIM(KL)=TWTIME
      XTDTIM(KL)=TDTIME
      XONORW(KL)=OONORW
      XONORT(KL)=OONORT
C
 4200 CONTINUE
C     TOTDT=XTDTIM(1)+XTDTIM(2)
      TOTDT=XTDTIM(1)
C     QUEUE 12
      AVAIL=100.-(TOTDT/(672.*AC))*100.
      ZVAIL3=AVAIL-ZZNORS
      IF(NEWFLG.EQ.1) GO TO 6000
      IF(NFLAG.EQ.0) DESNOR=TOTDT
      IF(NFLAG.EQ.0) GO TO 5020
      IF(NZFLAG.EQ.1) GO TO 4300
      ZTILU=TUIL
      ZAVAIL=AVAIL-ZZNORS
      NZFLAG=1
 4300 DESDT=DESNOR
      N1=TOTDT*10.
      N2=DESDT*10.
      IF(N1.EQ.N2) GO TO 5020
      GO TO (4500,4900,4400),NDTFLG
C
C-----DOWNTIME LOWER THAN DESIRED ON FIRST PASS
 4400 IF(N1.GT.N2) GO TO 4800
      UTLSAV=TUIL
      NDTFLG=1
      KNTDLT=1
 4500 IF(N1.LT.N2) GO TO 4550
 4525 KNTDLT=KNTDLT+1
      UTLNEW=OLDUTL*ELOW(KNTDLT)
      GO TO 4575
 4550 UTLNEW=UTLSAV*ELOW(KNTDLT)
      OLDUTL=TUIL
 4575 TUIL=UTLNEW
      UTLSAV=TUIL
      GO TO 70
C
C-----DOWNTIME HIGHER THAN DESIRED ON FIRST PASS
 4800 UTLSAV=TUIL
      NDTFLG=2
      KNTDLT=1
 4900 IF(N1.GT.N2) GO TO 4950
```

```
      KNTDLT=KNTDLT+1
      UTLNEW=OLDUTL*HIGH(KNTDLT)
      GO TO 4975
 4950 UTLNEW=UTLSAV*HIGH(KNTDLT)
      OLDUTL=TUIL
 4975 TUIL=UTLNEW
      UTLSAV=TUIL
      GO TO 70
C
C-----PRINT NORM AND NORS OUTPUT
C5020 XREORD(2)=XREORD(2)/24
 5020 CONTINUE
C     WRITE(6,5070)
      DO 5025 I=1,2
      IF(I.EQ.2) GO TO 5025
      WRITE(6,5030)                          AC, TILU
      WRITE(6,5010) XTBF(I), (NUMS(I,J),J=1,3), NX(I), (NCREW(I,J),J=1,2
     1), (INTVL(I,J),J=1,3), XREORD(I), (LENGTH(I,J),J=1,2), XXQ(I),
     2(NUNITS(I,J),J=1,2), XXWAIT(I), XXNUM(I), XXTIME(I), XZ(I)
      WRITE(6,5015) XTWTIM(I), XTDTIM(I), XONORW(I), XONORT(I)
 5025 CONTINUE
C     QUEUE 12
      AVAIL=AVAIL-ZZNORS
      WRITE(6,5017) ZZNORS,AVAIL
      PTILU=TILU
      PAVAIL=AVAIL
      IF(NFLAG.EQ.1.AND.NEWFLG.EQ.0) GO TO 60
      IF(IBER.EQ.1.AND.LR.EQ.1) GO TO 7000
      IF(IBER.EQ.1.AND.LR.NE.1) GO TO 50
      GO TO 6000
 5026 WRITE(6,5075)
C
C-----FORMAT STATEMENTS
 5000 FORMAT(1H1)
 5010 FORMAT( T5,'MEAN TIME BETWEEN MAINTENANCE',
     1 T36,F12.4,3X,'HOURS',/T5,3A4,T38,I5,7X,2A4,/
     2 T5,3A4,T39,F8.3,3X,2A4,/
     4 T5,'EXPECTED QUEUE LENGTH',T39,F9.4,2X,'TASKS',/
     5 T5,'EXPECTED WAITING TIME FOR ',2A4,T39,F9.4,2X,'HOURS',/
     6 T5,'EXPECTED NO. TASKS. IN SYSTEM',T39,F9.4,/
     7 T5,'EXPECTED TIME IN SYSTEM',T39,F9.4,2X,'HOURS',/
     8 T5,'PROBABILITY OF NO TASKS. IN SYSTEM',T41,F7.4)
 5015 FORMAT(   T5,'TOTAL WAITING TIME',T38,F10.4,T50,'HOURS (FAILS. X
     1EXP. WAIT TIME)',/T5,'TOTAL DOWN TIME',T38,F10.4,T50,'HOURS ( FAIL
     2S. X EXP. TIME IN SYS.)',/T5,'NORM- WAITING',T38,F10.4,T50,'% ( TO
     3T. WAIT TIME/TOT AC CAL. HRS.)',/T5,'NORM- TOTAL',T38,F10.4,T50,
     4'% ( TOT. DOWN TIME/TOT AC CAL. HRS.)')
 5017 FORMAT(/T5,'NORS - (INPUT)',T38,F10.4,T50,'%',
     1        //T5,'AVAILABILITY',T38,F10.4,T50,'%')
 5030 FORMAT(              ////T5,'NUMBER OF AIRCRAFT',T40,F4.0,/
     1 T5,'UTILIZATION',T40,F6.2,4X,'HRS/AC/MO')
 5040 FORMAT(T19,I3,T41,F7.4)
 5050 FORMAT(T41,F7.4)
 5060 FORMAT(///T5,'DESIRED NOR',2X,F7.4,1X,'%',///)
 5070 FORMAT(1H1)
 5075 FORMAT(1H1,///T3,'*** INPUT PARAMETERS RESULT IN CONSTANT QUEUE.',
     1 ' EXECUTION STOPPED. ',//)
 5100 FORMAT(/  T90,'ATTEMPTED UTIL. OF ',F5.1,' HRS.',
     1/T90,'IS TOO HIGH',/)
      STOP
 6000 RETURN
 7000 STOP
      END
```

AD-A042 134 BOEING VERTOL CO PHILADELPHIA PA F/G 1/3
PRODUCT IMPROVEMENT PROGRAM EVALUATION.(U)
JUN 77 S J BLEWITT DAAJ02-76-C-0020
UNCLASSIFIED D210-11146-2 USAAMRDL-TR-77-17 NL

2 OF 2
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      SUBROUTINE FACTOR(N,FA)
      DIMENSION FA(100)
      COMMON ILT(100),INLEGS(100),ILGDIS(100),IMISND(100),
     1                           IMTYP(100), IMD(100), INPAS(100),
     2 INLIT(100),INCAR(100),ICLS(100),IMLOAD(100)
      FA(1)=0.
      DO 10 I=2,N
      X=I
   10 FA(I)=FA(I-1)+ALOG(X)
      RETURN
      END
```

```
416         SUBROUTINE INCORP(MODTT1,MODTT2,MODTT3,MODTT4,NUMOL,NUMEW,NOLTOT,
           1 NEWTOT,LOCMFH,NACMFH,NAC,NFHYR,IYR,NOL,NNE,LFLAG)
417         DIMENSION MOAC(240), MOUTIL(240), INC1(240), INC2(240),NAME(3),
           1 INC3(240),OLRATE(3),EWRATE(3),NUMOL(20,3),NUMEW(20,3),NOLTOT(3),
           1 NEWTOT(3),NFHYR(20,2),FACTOR(20),NOL(20),NNE(20),NY(2)
418         COMMON ILT(100),INLEGS(100),ILGDIS(100),IMISND(100),
           1                             IMTYP(100), IMD(100), INPAS(100),
           2 INLIT(100),INCAR(100),ICLS(100),IMLOAD(100)
419         DATA NY/' YES',' NO'/,MOAC/240*0/
420         DO 300 I=1,20
421         DO 300 J=1,3
422         IF(J.NE.3) NFHYR(I,J)=0
423         NUMOL(I,J)=0
424     300 NUMEW(I,J)=0
425         READ(5,400) MONTHS,NACSTR,NDLVCD,MODLV,MOS,NDLWMD,MOSTRT,
           A NFHCD,MOFH,
           1 MODTT4, (OLRATE(I),EWRATE(I),I=1,3),NAME
426         READ(5,410) INSCD1,LEVEL1,MEVEL1,MODTT1,MMSTRT,LOCAL,LINPIP,
           1 ACATR,NCOMP
427         IF(LOCAL.EQ.0) LOCAL=1
428         IF(LINPIP.EQ.0) LINPIP=4
429         IF(ACATR.EQ.0.) ACATR=2.
430         IF(NDLVCD.EQ.0) NDLVCD=2
431         IF(NDLWMD.EQ.0) NDLWMD=2
432         IF(NFHCD.EQ.0) NFHCD=2
433         IF(INSCD1.EQ.0) INSCD1=2
434         IYR=MONTHS/12
435         OLMTBF=OLRATE(1)
436         EWMTBF=EWRATE(1)
437     400 FORMAT(I3,I4,I1,I2,I3,I1,I3,I1,I3,I4,6(F7.1),3A4)
438     410 FORMAT(I1,2I3,I4,I3,2I2,F6.2,I2)
439         WRITE(6,2000)NAME,MONTHS,NACSTR,NY(NDLVCD),MODLV,MOS,NY(NDLWMD),
           1 MOSTRT, NY(NFHCD), MOFH
440         WRITE(6,2001)                MODTT4, NY(INSCD1), LEVEL1, MEVEL1,
           2 MODTT1, MMSTRT,LOCAL,LINPIP,ACATR,
           3                  (OLRATE(I),EWRATE(I),I=1,3)
      C
      C-----IF DELIVERIES ARE AT A CONSTANT RATE
441         IF(NDLVCD.EQ.1) GO TO 525
442         IF(MOS.EQ.0) GO TO 575
443         DO 500 I=1,MOS
444     500 MOAC(I)=MODLV
445         GO TO 575
      C-----IF DELIVERIES ARE AT AN IRREGULAR RATE
446     525 K=MOS/24
447         KREM=MOS-(K*24)
448         L=-23
449         M=0
450         IF(K.LE.0) GO TO 550
451         DO 535 I=1,K
452         L=L+24
453         M=M+24
454     535 READ 537, (MOAC(J),J=L,M)
455     537 FORMAT(26I3)
456     550 L=L+24
457         M=M+KREM
458         READ 537, (MOAC(J),J=L,M)
      C-----IF FLT. HRS. ARE AT A CONSTANT RATE
459     575 IF(NFHCD.EQ.1) GO TO 625
460         DO 600 I=1,MONTHS
```

```
  600 MOUTIL(I)=MOFH
      GO TO 675
C-----IF FLT. HRS. ARE AT AN IRREGULAR RATE
  625 K=MONTHS/24
      KREM=MONTHS-(K*24)
      L=-23
      M=0
      IF(K.LE.0) GO TO 650
      DO 635 I=1,K
      L=L+24
      M=M+24
  635 READ 537, (MOUTIL(J),J=L,M)
  650 L=L+24
      M=M+KREM
      READ 537, (MOUTIL(J),J=L,M)
C-----INSTALLATIONS
C
C-----CONSTANT RATE - LEVEL 1
  675 IF(INSCD1.EQ.1) GO TO 725
      DO 700 I=1,MONTHS
  700 INC1(I)=LEVEL1
      GO TO 775
C-----IRREGULAR RATE
  725 K=MEVEL1/24
      KREM=MEVEL1-(K*24)
      L=-23
      M=0
      IF(K.LE.0) GO TO 750
      DO 735 I=1,K
      L=L+24
      M=M+24
  735 READ 537, (INC1(J),J=L,M)
  750 L=L+24
      M=M+KREM
      READ 537, (INC1(J),J=L,M)
  775 LODFLS=0
      NEWFLS=0
      LOCMFH=0
      NWCMFH=0
      LODREM=0
      NWREM=0
      NAC=NACSTR
      ITMSOL=NACSTR
      ITMSNW=0
C-----MAJOR LOOP - (MONTHS)
      DO 1001 J=1,MONTHS
C-----AIRCRAFT STILL BEING DELIVERED
      IF(J.GT.MOS) GO TO 895
      NAC=NAC+MOAC(J)
      IF(J.LT.MOSTRT) GO TO 890
      IF(MODTT4.LE.0) GO TO 890
      IF(NDLWMD.EQ.1) ITMSNW=ITMSNW+MOAC(J)
  885 MODTT4=MODTT4-MOAC(J)
  890 IF(NDLWMD.NE.1) ITMSOL=ITMSOL+MOAC(J)
      IF(NDLWMD.EQ.1.AND.MOSTRT.GT.J) ITMSOL=ITMSOL+MOAC(J)
C-----FLT. HRS.
C     INCORP 1,3
  895 LODFH=ITMSOL*MOUTIL(J)+LODREM
      NWFH=ITMSNW*MOUTIL(J)+NWREM
      LOCMFH=LOCMFH+(ITMSOL*MOUTIL(J))
```

```
      NWCMFH=NWCMFH+(ITMSNW*MOUTIL(J))
C-----FAILURES
C     INCORP 2
      MLDFLS=LODFH/OLMTBF
      LODREM=LODFH-(MLDFLS*OLMTBF)
      LODFLS=LODFLS+MLDFLS
      IF(EWMTBF.GT.0) GO TO 8950
      MNWFLS=0
      GO TO 8951
 8950 MNWFLS=NWFH/EWMTBF
 8951 NWREM=NWFH-(MNWFLS*EWMTBF)
      NEWFLS=NEWFLS+MNWFLS
C-----YEARLY FAILURES (CUM)
      YR=J/12.
      MYR=YR
      REM=YR-MYR
      IF(REM.NE.0) GO TO 898
      DO 897 L=1,3
      IF(OLRATE(L).LE.0) GO TO 896
      NUMOL(MYR,L)=LOCMFH/OLRATE(L)
  896 IF(EWRATE(L).LE.0) GO TO 897
      NUMEW(MYR,L)=NWCMFH/EWRATE(L)
  897 CONTINUE
C-----YEARLY FLT.HRS.
      IF(MYR.EQ.1) NFHYR(MYR,1)=LOCMFH
      IF(MYR.EQ.1) NFHYR(MYR,2)=NWCMFH
      IF(MYR.NE.1) NFHYR(MYR,1)=LOCMFH-LOPREV
      IF(MYR.NE.1) NFHYR(MYR,2)=NWCMFH-NWPREV
      LOPREV=LOCMFH
      NWPREV=NWCMFH
C-----INCORPORATIONS OR INSTALLATIONS
C
C-----LEVEL 1
  898 IF(MODTT1.LE.0) GO TO 910
      IF(J.LT.MMSTRT) GO TO 910
      IF(ITMSOL.LT.INC1(J)) GO TO 905
      ITMSNW=ITMSNW+INC1(J)
      ITMSOL=ITMSOL-INC1(J)
      MODTT1=MODTT1-INC1(J)
      GO TO 910
  905 ITMSNW=ITMSNW+ITMSOL
      MODTT1=MODTT1-ITMSOL
      ITMSOL=0
  910 CONTINUE
      IF(REM.EQ.0) NOL(MYR)=ITMSOL
 1001 IF(REM.EQ.0) NNE(MYR)=ITMSNW
      NAC=ITMSOL+ITMSNW
C-----FAILURES BY YEAR (NOT CUM)
C     INCORP 6
      DO 1005 I=1,3
      NOLTOT(I)=NUMOL(1,I)
 1005 NEWTOT(I)=NUMEW(1,I)
      N=21
 1010 N=N-1
      IF(N.EQ.1) GO TO 1050
      DO 1025 I=1,3
      M=N-1
      NUMOL(N,I)=NUMOL(N,I)-NUMOL(M,I)
      NUMEW(N,I)=NUMEW(N,I)-NUMEW(M,I)
      IF(NUMOL(N,I).LE.0) NUMOL(N,I)=0
```

```
      IF(NUMEW(N,I).LE.0) NUMEW(N,I)=0
      NOLTOT(I)=NOLTOT(I)+NUMOL(N,I)
      NEWTOT(I)=NEWTOT(I)+NUMEW(N,I)
 1025 CONTINUE
      GO TO 1010
 1050 NTOTFH=LOCMFH+NWCMFH
C-----CALCULATE SPARES AND ATTRITED AC
C     INCORP 5
      IF(LFLAG.EQ.1) NACATR=LOCMFH/100000.*ACATR
      IF(LFLAG.EQ.2) NACATR=NWCMFH/100000.*ACATR
C     INCORP 4
      SPRHRS=(LOCAL+LINPIP)*(NTOTFH/MONTHS)
      NSPARS=0
      SPARS=0.
      IF(OLRATE(2).GT.0)  SPARS=SPRHRS/OLRATE(2)
      IF(NEWTOT(2).NE.0.AND.EWRATE(2).GT.0)  SPARS=SPRHRS/EWRATE(2)
      NSPARS=SPARS
      IF(NSPARS.LT.NCOMP) GO TO 1100
      IF(NSPARS.EQ.NCOMP) GO TO 1200
      SPARES=SPARS/NCOMP+.5
      NSPARS=SPARES
      GO TO 1200
 1100 NSPARS=NCOMP
 1200 WRITE(6,2100)  (NOLTOT(I),NEWTOT(I),I=1,3)
      WRITE(6,2050) LOCMFH,NWCMFH
      WRITE(6,2060) NSPARS,NACATR
C-----FORMAT STATEMENTS
 2000 FORMAT(1H1,///T2, 'MODIFICATION INCORPORATION DATA - ',3A4,
     A ///T3,'I N P U T S : ',
     1 //T3,'NO. OF MONTHS IN STUDY',T35,I4,
     2  /T3,'NO. OF COMPONENTS IN FLEET     ',T35,I4,
     3  /T3,'IRREG. DELIVERY RATE ?         ',T35,1A4,
     4  /T3,'IF CONSTANT, DELIVS. PER MO.   ',T35,I4,
     5  /T3,'NO. OF MONTHS                  ',T35,I4,
     6  /T3,'AC DELIVERED WITH MOD ?        ',T35,1A4,
     7  /T3,'START MONTH                    ',T35,I4,
     8  /T3,'IRREG. UTILIZATION ?           ',T35,1A4,
     9  /T3,'FLT. HRS./COMP./MO.            ',T35,I4)
 2001 FORMAT(
     A    T3,'TOTAL AC DELIV. WITH MOD      ',T35,I4,
     B  /T3,'IRREG. FIELD MOD INCORP. RATE ?',T35,1A4,
     C  /T3,'IF CONSTANT, INCORPS. PER MO.  ',T35,I4,
     D  /T3,'IF IRREG., NO. OF MONTHS       ',T35,I4,
     E  /T3,'TOTAL INCORPORATED             ',T35,I4,
     F  /T3,'START MONTH                    ',T35,I4,
     F /T3,'QTY. SPARES ON HAND',T35,I4,' MONTHS',
     F /T3,'QTY. PIPELINE SPARES',T35,I4,' MONTHS',
     F /T3,'COMP. ATTR.  RATE/100000 HRS.',T36,F6.2,//
     G T22,'OLD ITEM    NEW ITEM',/T3,'MTBF',T23,2(F7.2,4X ),/T3,'MTBR TO
     H AVIM',T22,2(F8.2,3X),/T3,'MTBR TO DEPOT',T22,2(F8.2,3X))
 2050 FORMAT( /T3,'FLT. HRS.',T22,2(I8,3X))
 2060 FORMAT(//T3,'INIT. SPARES REQ. PER LOC.',T29,I4,/T3,
     1 'COMPS. ATTRITED',T29,I4)
 2100 FORMAT(/////T3,'O U T P U T S :',//T22,'OLD ITEM   NEW ITEM',
     1 /T3,'MAINT. ACTIONS AT',/T3,'AVUM',T23,2(I7,4X),/T3,'AVIM',
     2 T23,2(I7,4X),/T3,'DEPOT',T23,2(I7,4X))
      RETURN
      END
```

```
      SUBROUTINE ZCOST(NUMOL,NUMEW,NOLTOT,NEWTOT,JFLAG,LOCMFH,NWCMFH,
     1 OUT,COST,NFHYR,ZOM,VVEST,NCHKYR,TMMPP)
      COMMON ILT(100),INLEGS(100),ILGDIS(100),IMISND(100),
     1                            IMTYP(100), IMD(100), INPAS(100),
     2 INLIT(100),INCAR(100),ICLS(100),IMLOAD(100)
      DIMENSION HMM(3),PARTS (3),NOCPM (20),OUT(60),NCODE(5),FACTOR(20),
     1 NRD(5),NIN(20),NIR(20),NFHYR(20,2),         NOLTOT(3),NEWTOT(3),
     2 HMMN(3),PARTSN(3),NUMOL(20,3),NUMEW(20,3),COST(20,3),ZOM(20),
     3 RATLAB(3),NY(2)
      DATA NY/' YES',' NO'/
      DO 20 I=1,60
   20 OUT(I)=0.
      DO 25 I=1,20
      DO 25 J=1,3
   25 COST(I,J)=0.
      VVEST=0.
C-----READ OPERATIONAL COST DATA
C
C-----SUFFIX C=CONTRACT, I=IN-HOUSE, O=OLD ITEM, N=NEW ITEM
      READ(5,100) NDL,CRATE,HMM(3),PARTS (3),PARTS (1),HMM(1),POLRA,
     1 PARTS (2),HMM(2),LBSO
      PDL=NDL
      PDL=PDL/100.
      POLRA =POLRA /6.7
      READ(5,100) NDLN,CRATEN,HMMN(3),PARTSN(3),PARTSN(1),HMMN(1),
     1 POLRAN, PARTSN(2),HMMN(2),LBSN
      READ(5,105) NOCPM
      PDLN=NDLN
      PDLN=PDLN/100.
      POLRAN=POLRAN/6.7
C-----READ CONSTANT FACTORS
      READ(5,110) OHD,GNA,PROFIT,XPORTC,(RATLAB(I),I=1,3),XPORTI,CJP,FI
      IF(OHD.EQ.0) OHD=180.
      IF(GNA.EQ.0) GNA=17.
      IF(PROFIT.EQ.0) PROFIT=10.
      IF(XPORTC.EQ.0) XPORTC=17.
      IF(RATLAB(1).EQ.0) RATLAB(1)=10.
      IF(RATLAB(2).EQ.0) RATLAB(2)=11.
      IF(RATLAB(3).EQ.0) RATLAB(3)=13.50
      IF(XPORTI.EQ.0) XPORTI=13.
      IF(CJP.EQ.0) CJP=.45
      IF(FI.EQ.0) FI=10.
C-----PRINT INPUT
      IF(JFLAG.EQ.0) WRITE(6,2000)
      IF(JFLAG.EQ.1) WRITE(6,2010)
      WRITE(6,2100) OHD,GNA,PROFIT,XPORTC,XPORTI,RATLAB,CJP,FI
      WRITE(6,2200) NDL,NDLN,CRATE,CRATEN,HMM(3),HMMN(3),HMM(1),HMMN(1),
     1 HMM(2),HMMN(2),PARTS(3),PARTSN(3),PARTS(1),PARTSN(1),PARTS(2),
     2 PARTSN(2),LBSO,LBSN,POLRA,POLRAN
      OHD=OHD/100.+1.
      GNA=GNA/100.
      PROFIT=PROFIT/100.
      FI=FI/100.
      WRITE(6,2300) (I,NOCPM(I),I=1,20)
      IF(JFLAG.EQ.0) GO TO 200
C-----READ R&D COSTS
      READ(5,115) OUT(3),NCODE(1),OUT(4),NCODE(2),OUT(5),NCODE(3),
     1 OUT(6),NCODE(4),(OUT(I),I=7,9),OUT(11), OUT(1),NRDEST
      SUM=0.
      DO 30 I=1,4
```

```
      J=I+2
      IF(NCODE(I).NE.1) OUT(J)=OUT(J)*OHD
      IF(NCODE(I).EQ.0) NCODE(I)=2
   30 SUM=SUM+OUT(J)
      IF(NRDEST.EQ.0) NRDEST=2
C-----PRINT INPUT
      WRITE(6,2010)
      WRITE(6,2400) (OUT(I),NY(NCODE(I-2)),I=3,6),(OUT(I),I=7,9),
     1 OUT(11),OUT(1),NY(NRDEST)
      IF(OUT(7).EQ.0) OUT(7)=SUM*GNA
      SUM=SUM+OUT(7)
      IF(OUT(8).EQ.0) OUT(8)=SUM*PROFIT
      SUM=SUM+OUT(8)
      OUT(2)=SUM
      OUT(10)=OUT(11)
      SUM=SUM+OUT(11)
      IF(OUT(1).EQ.0) OUT(1)=SUM
      READ(5,105) NRD
C-----READ INVESTMENT NONRECURRING COSTS
      READ(5,120) OUT(16),NCODE(1),OUT(17),NCODE(2),OUT(18),NCODE(3),
     1 OUT(19),NCODE(4),OUT(20),NCODE(5),OUT(21),OUT(22),OUT(24),
     2 OUT(14),NINEST
      SUM=0.
      DO 35 I=1,5
      J=I+15
      IF(NCODE(I).NE.1) OUT(J)=OUT(J)*OHD
      IF(NCODE(I).EQ.0) NCODE(I)=2
   35 SUM=SUM+OUT(J)
      IF(NINEST.EQ.0) NINEST=2
C-----PRINT INPUT
      WRITE(6,2500) (OUT(I),NY(NCODE(I-15)),I=16,20),OUT(21),OUT(22),
     1 OUT(24),OUT(14),NY(NINEST)
      IF(OUT(21).EQ.0) OUT(21)=SUM*GNA
      SUM=SUM+OUT(21)
      IF(OUT(22).EQ.0) OUT(22)=SUM*PROFIT
      SUM=SUM+OUT(22)
      OUT(15)=SUM
      OUT(23)=OUT(24)
      SUM=SUM+OUT(24)
      IF(OUT(14).EQ.0) OUT(14)=SUM
      READ(5,105) NIN
C-----READ INVESTMENT RECURRING COST DATA
      READ(5,125) OUT(29),NCODE(1),OUT(30),NCODE(2),OUT(31),NCODE(3),
     1 OUT(32), NCODE(4), OUT(33),OUT(34), NUNITC, OUT(35), LBSC,
     2 OUT(36)
      READ(5,130) OUT(38),OUT(39),NUNITI,LBSI,OUT(27),NIREST,OUT(40)
      SUM=0.
      DO 40 I=1,4
      J=I+28
      IF(NCODE(I). NE.1) OUT(J)=OUT(J)*OHD
      IF(NCODE(I).EQ.0) NCODE(I)=2
   40 SUM=SUM+OUT(J)
      IF(NIREST.EQ.0) NIREST=2
C-----PRINT INPUT
      WRITE(6,2600) (OUT(I),NY(NCODE(I-28)),I=29,32), (OUT(I),I=33,36),
     1 OUT(38),OUT(39),OUT(40),OUT(27),NY(NIREST)
C-----CONTRACT TRANSPORTATION COSTS
      IF(OUT(33).NE.0) GO TO 45
      IF(NUNITC.EQ.0) GO TO 45
      TOTWT=NUNITC*LBSC
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```
      SHPWT=TOTWT/100.
      OUT(33)=SHPWT**PORTC
   45 SUM=SUM+OUT(33)+OUT(34)
      IF(OUT(35).EQ.0) OUT(35)=SUM*GNA
      SUM=SUM+OUT(35)
      IF(OUT(36).EQ.0) OUT(36)=SUM*PROFIT
      SUM=SUM+OUT(36)
      OUT(28)=SUM
C-----IN-HOUSE TRANSPORTATION COSTS
      IF(OUT(38).NE.0) GO TO 50
      IF(NUNITI.EQ.0) GO TO 50
      TOTWT=NUNITI*LBSI
      SHPWT=TOTWT/100.
      OUT(38)=SHPWT*XPORTI
   50 OUT(37)=OUT(38)+OUT(39)
      SUM=SUM+OUT(37)
      IF(OUT(27).EQ.0) OUT(27)=SUM
      READ(5,105) NIR
C-----PRINT INPUT
      WRITE(6,2020)
      WRITE(6,2700) (I,NRD(I),NIN(I),NIR(I),I=1,5), (I,NIN(I),NIR(I),
     1 I=6,20)
C-----FORMAT STATEMENTS - READ
  100 FORMAT(I3,F5.2,F6.1,F8.2,F6.2,F5.1,F5.1,F6.2,F5.1,I3)
  105 FORMAT(10I8)
  110 FORMAT(3F6.2,5F5.2,F4.2,F4.1)
  115 FORMAT(3(F7.0,I1),F6.0,I1,2F6.0,F3.0,F7.0,F8.0,I1)
  120 FORMAT(4(F7.0,I1),F6.0,I1,2F6.0,F7.0,F8.0,I1)
  125 FORMAT(3(F7.0,I1),F8.0,I1,2F7.0,I5,F7.0,I3,F7.0)
  130 FORMAT(2F7.0,I5,I3,F9.0,I1,F4.0)
C-----CALCULATE OPERATING COSTS
C
C-----CONTRACT TRANSPORTATION COSTS
C     ZCOST 1
  200 NDOHC =NOLTOT(3)*PDL
      NDOHCN=NEWTOT(3)*PDLN
C     ZCOST 2
      SHPWT=NDOHC *2*LBSO/100.
      SHPWTN=NDOHCN*2*LBSN/100.
C     ZCOST 4
      OUT(46)=SHPWT*XPORTC+SHPWTN*XPORTC
C     ZCOST 3
      BURDEN=OHD+GNA+PROFIT
      OUT(46)=OUT(46)*BURDEN
C-----CONTRACT DEPOT LABOR & PARTS
C     ZCOST 5,6
      OUT(47)=(NDOHC*HMM(3)*CRATE+NDOHCN*HMMN(3)*CRATEN)
      OUT(47)=(OUT(47)+(NDOHC*PARTS(3)+NDOHCN*PARTSN(3)))*BURDEN
      DO 210 I=45,48
  210 OUT(44)=OUT(44)+OUT(I)
C-----IN-HOUSE LABOR & PARTS
C     ZCOST 7,10,11
      NDOHI =NOLTOT(3)-NDOHC
      NDOHIN=NEWTOT(3)-NDOHCN
C     ZCOST 14
      OUT(55)=NDOHI*HMM(3)*RATLAB(3)+(NDOHI*PARTS(3))
      OUT(55)=OUT(55)+NDOHIN*RATLAB(3)*HMMN(3)+(NDOHIN*PARTSN(3))
      DO 225 I=1,2
      OUT(50)=OUT(50)+NOLTOT(I)*RATLAB(I)*HMM(I)
      OUT(50)=OUT(50)+NEWTOT(I)*RATLAB(I)*HMMN(I)
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      OUT(52)=OUT(52)+NOLTOT(I)*PARTS(I)
  225 OUT(52)=OUT(52)+NEWTOT(I)*PARTSN(I)
C     ZCOST 8
C-----POL
      OUT(53)=(LOCMFH*POLRA*CJP)+(NWCMFH*POLRAN*CJP)
C     ZCOST 9
      OUT(51)=OUT(52)+OUT(53)
C-----IN-HOUSE TRANSPORTATION COSTS
C     ZCOST 12,13
      SHPWT=NDOHI*2*LBSO/100.
      SHPWTN=NDOHIN*2*LBSN/100.
      OUT(54)=(SHPWT+SHPWTN)*XPORTI
      DO 235 I=1,20
C     ZCOST 15
  235 OUT(56)=OUT(56)+NOCPM(I)
      DO 250 I=50,56
      IF(I.EQ.52.OR.I.EQ.53) GO TO 250
      OUT(49)=OUT(49)+OUT(I)
  250 CONTINUE
C     ZCOST 16
      OUT(43)=OUT(44)+OUT(49)
C-----ESTIMATE NON-OPERATING COST CATEGORY AMOUNTS
      IF(JFLAG.EQ.0) TMMPP=OUT(43)-OUT(53)
      IF(JFLAG.EQ.0) GO TO 280
      TEMP=TMMPP
      IF(JFLAG.EQ.1.AND.NRDEST.EQ.1) OUT(1)=TEMP*.05
      IF(JFLAG.EQ.1.AND.NINEST.EQ.1) OUT(14)=TEMP*.014167
      IF(JFLAG.EQ.1.AND.NIREST.EQ.1) OUT(27)=TEMP*.269167
C-----ESTIMATED NON-OP COSTS PER YEAR
      IF(NRDEST.EQ.1) NRD(1)=OUT(1)
      IF(NINEST.EQ.1) NIN(2)=OUT(14)
      IF(NIREST.NE.1) GO TO 280
      DO 275 N=3,5
  275 NIR(N)=OUT(27)/3.
  280 DO 1000 I=1,20
C-----YEARLY OPERATING COSTS
C
C-----CONTRACT TRANSPORTATION COSTS TO DEPOT
       DOHCO=NUMOL(I,3)*PDL
       DOHCN=NUMEW(I,3)*PDLN
      SHPWTO= DOHCO*2*LBSO/100.
      SHPWTN= DOHCN*2*LBSN/100.
      COST(I,1)=COST(I,1)+((SHPWTO+SHPWTN)*XPORTC)
C-----DEPOT LABOR AND PARTS
      COST(I,1)=COST(I,1)+( DOHCO*HMM(3)*CRATE+ DOHCN*HMMN(3)*CRATEN)
      COST(I,1)=COST(I,1)+( DOHCO*PARTS(3)+ DOHCN*PARTSN(3))
C-----APPLY OVERHEAD
      COST(I,1)=COST(I,1)*BURDEN
C-----IN-HOUSE LABOR & PARTS
C
C-----DEPOT
       DOHIO=NUMOL(I,3)- DOHCO
       DOHIN=NUMEW(I,3)- DOHCN
      TEMP= DOHIO*RATLAB(3)*HMM(3)+ DOHIO*PARTS(3)
      TEMP=TEMP+( DOHIN*RATLAB(3)*HMMN(3)+ DOHIN*PARTSN(3))
      COST(I,1)=COST(I,1)+TEMP
C-----AVUM & AVIM
      TEMP=0.
      DO 300 J=1,2
      TEMP=TEMP+(NUMOL(I,J)*RATLAB(J)*HMM(J)+NUMOL(I,J)*PARTS(J))
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  300 TEMP=TEMP+(NUMEW (I,J)*RATLAB(J)*HMMN(J)+NUMEW(I,J)*PARTSN(J))
      COST(I,1)=COST(I,1)+TEMP
C-----POL
      TEMP=(NFHYR(I,1)*POLRA*CJP)+(NFHYR(I,2)*POLRAN*CJP)
      COST(I,1)=COST(I,1)+TEMP
C-----IN-HOUSE TRANSPORTATION COSTS TO DEPOT
      SHPWTO= DOHIO*2*LBSO/100.
      SHPWTN= DOHIN*2*LBSN/100.
      COST(I,1)=COST(I,1)+((SHPWTO+SHPWTN)*XPORTI)
      COST(I,1)=COST(I,1)+NOCPM(I)
      ZOM(I)=COST(I,1)
      IF(JFLAG.EQ.0) GO TO 900
C-----ADD IN OTHER COST CATEGORIES BY YEAR
      IF(I.GT.5) GO TO 800
      IF(NRD(I).NE.0) NCHKYR=I
  800 IF(NIN(I).NE.0.OR.NIR(I).NE.0) NCHKYR=I
C     ZCOST 17
      COST(I,1)=COST(I,1)           +NIN(I)+NIR(I)
      IF(I.LT.6) COST(I,1)=COST(I,1)+NRD(I)
C-----CALCULATE CUM & DISCOUNTED COSTS
  900 COST(1,2)=COST(1,1)
      XI=I
      COST(1,3)=COST(1,1)*((1.+FI)**(-(1.-.5)))
      M=I-1
C     ZCOST 17
      IF(I.GT.1) COST(I,2)=COST(M,2)+COST(I,1)
C     ZCOST 18
      IF(I.GT.1) COST(I,3)=COST(M,3)+(COST(I,1)*((1.+FI)**(-(XI-.5))))
C-----DISCOUNT INVESTMENT
      IF(JFLAG.EQ.0) GO TO 1000
C     ZCOST 19
      IF(I.LT.6) VTEMP=NRD(I)+NIN(I)+NIR(I)
      IF(I.GT.5) VTEMP=NIN(I)+NIR(I)
      IF(I.GT.1) GO TO 990
      VVEST=VTEMP*((1.+FI)**(-(.5)))
      GO TO 995
  990 VVEST=VVEST+(VTEMP*((1.+FI)**(-(XI-.5))))
  995 CONTINUE
 1000 CONTINUE
C-----FORMAT STATEMENTS - PRINT INPUT
 2000 FORMAT(1H1,//T22,'COST INPUT DATA - BASELINE')
 2010 FORMAT(1H1,//T22,'COST INPUT DATA - ALTERNATE')
 2020 FORMAT(1H1,//T16,'COST INPUT DATA - ALTERNATE',///T3,
     1 'INVESTMENT COSTS BY YEAR : ',//T24,'NON',/T3,'YEAR',T15,
     2 'R&D   RECURRING   RECURRING',/)
 2100 FORMAT(///T3,'CONSTANT FACTORS :',/T5,'OVERHEAD',T47,F6.2,1X,'%',
     1 /T5,'G&A',T47,F6.2,1X,'%',/T5,'PROFIT',T47,F6.2,1X,'%',/T5,
     2 'SHIPPING RATE - CONTRACT',T46,'$',T48,F5.2,1X,'PER 100 LBS.',
     3 /T21,'IN-HOUSE',T48,F5.2,1X,'PER 100 LBS.',/T5,'ARMY LABOR RATE -
     4 AVUM',T48,F5.2,1X,'PER HR.',/T23,'AVIM',T48,F5.2,1X,'PER HR.',
     5 /T23,'DEPOT',T48,F5.2,1X,'PER HR.',/T5,'FUEL COST',T48,F5.2,1X,
     6 'PER GALLON',/T5,'DISCOUNT RATE',T47,F6.2,1X,'%')
 2200 FORMAT(///T3,'OPERATING COST DATA :',T45,'OLD ITEM',T65,'NEW ITEM'
     1 ,/T5,'% DEPOT MAINT. PERFORMED BY CONTR.',T47,I3,  1X,'%',T67,
     2 I3,  1X,'%',/T5,'UNBURNDENED RATE',T44,'$',T48,F5.2,1X,'PER HR.'
     3,T64,'$',T68,F5.2,1X,'PER HR.',/T5,'AVG. MMH TO REPAIR AT DEPOT',
     4 T46,2(F7.2,13X),/T27,'AVUM',T47,2(F6.2,14X),/T27,'AVIM',T47,
     5 2(F6.2,14X),/T5,'AVG. VALUE OF PARTS CONSUMED AT DEPOT $ ',F8.2,
     6 T63,'$ ',F8.2,/T37,'AVUM',T47,2(F6.2,14X),/T37,'AVIM',T47,
     7 2(F6.2,14X),/T5,'PART SHIPPING WEIGHT',T47,I3,4X,'LBS.',T67,I3,
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     8 4X,'LBS.',/T5,'SFC PER FLT. HR.',T47,F6.2,1X,'LBS.',T67,F6.2,1X,
     9 'LBS.',///T3,'PROGRAM MGMT. COST PER YEAR :',/)
 2300 FORMAT(20(/T36,I2,5X,I8))
 2400 FORMAT(//T3,'R+D COSTS',T49,'OVERHEAD ALREADY',/T5,'CONTRACT',
     1 T51,'INCLUDED ?',/T7,'ENGINEERING',T38,F9.0,7X,1A4,/T7,'TOOLING',
     2 T38,F9.0,7X,1A4,/T7,'PROTOTYPE PRODUCTION',T38,F9.0,7X,1A4,/T7,
     3 'OTHER',T38,F9.0,7X,1A4,/T7,'G&A',T38,F9.0,/T7,'PROFIT',T38,F9.0,
     4 /T7,'QTY. OF PROTOTYPES',T38,F9.0,/T5,'IN-HOUSE',/T7,'PROGRAM MGM
     5T.',T38,F9.0,/T3,'IF ELEMENTS NOT BROKEN OUT, TOTAL  ',F9.0,/T3,
     6 'ESTIMATE R&D COSTS ?',T42,1A4)
 2500 FORMAT(//T3,'INVESTMENT NONRECURRING COSTS',/T5,'CONTRACT',/T7,
     1 'ADV PROD ENGINEERING',T38,F9.0,7X,1A4,/T7,'TOOLING',T38,F9.0,7X,
     2 1A4,/T7,'MANUFACTURING',T38,F9.0,7X,1A4,/T7,'QUALITY CONTROL',
     3 T38,F9.0,7X,1A4,/T7,'OTHER',T38,F9.0,7X,1A4,/T7,'G&A',T38,F9.0,
     4 /T7,'PROFIT',T38,F9.0,/T5,'IN-HOUSE',/T7,'PROGRAM MGMT.',T38,
     5 F9.0,/T3,'IF ELEMENTS NOT BROKEN OUT, TOTAL  ',F9.0,/T3,
     6 'ESTIMATE NONRECURRING COSTS ?',T42,1A4)
 2600 FORMAT(//T3,'INVESTMENT RECURRING COSTS',/T5,'CONTRACT',/T7,
     1 'ENGINEERING',T38,F9.0,7X,1A4,/T7,'TOOLING',T38,F9.0,7X,1A4,/T7,
     2 'QUALITY CONTROL',T38,F9.0,7X,1A4,/T7,'MANUFACTURING',T38,F9.0,
     3 7X,1A4,/T7,'FIRST DEST. TRANSPORTATION',T38,F9.0,/T7,'OTHER',
     4 T38,F9.0,/T7,'G&A',T38,F9.0,/T7,'PROFIT',T38,F9.0,/T5,'IN-HOUSE',
     5          /T7,'TRANSPORTATION',T38,F9.0,/T7,'PROGRAM MGMT.',T38,
     6 F9.0,/T5,'TOTAL QTY.',T40,F7.0,/T3,'IF ELEMENTS NOT BROKEN OUT, T
     7OTAL',T38,F9.0,/T3,'ESTIMATE RECURRING COSTS ?',T42,1A4)
 2700 FORMAT(5(/,4X,I2,3(3X,I8  )),15(/,4X,I2,14X,I8,  3X,I8  ))
      RETURN
      END
```

PROGRAM OUTPUT

```
AIRCRAFT -   47C BASELINE
CLASS -  1


PAYLOAD  --------------- 24000 LBS
CRUISE SPEED (KMPH)
    INTERNAL  ----------  259
    EXTERNAL  ----------  238

CABIN COMPARTMENT
  FLOOR AREA -----------  240 SQ.FT.
  NUMBER OF SEATS ------   44
  NUMBER OF LITTERS ----   24
    AMBULATORY SEATS ---    2
```

MISSION NO	MISSION TYPE	MISSION CLS	LEG TYPE	LEG NO	DIST	NUMBER OF PAX	NUMBER OF LITS	CARGO POUNDS	INDV LOAD	SORTIES	FLT. HRS.
1	6	1	1	1	255	212872	0	65022720	1	4838	2,036
										4838	9849,094

NUMBER OF AIRCRAFT	16,	
UTILIZATION	50,00	HRS/AC/MO
MEAN TIME BETWEEN MAINTENANCE	0,7505	HOURS
TO & E SIZE	6	CREWS
MTTR	2,150	HOURS
EXPECTED QUEUE LENGTH	0,2125	TASKS
EXPECTED WAITING TIME FOR MEN	0,1340	HOURS
EXPECTED NO. TASKS. IN SYSTEM	3,6229	
EXPECTED TIME IN SYSTEM	2,2840	HOURS
PROBABILITY OF NO TASKS. IN SYSTEM	0,0319	
TOTAL WAITING TIME	142,7950	HOURS (FAILS. X EXP. WAIT TIME)
TOTAL DOWN TIME	2434,5980	HOURS (FAILS. X EXP. TIME IN SYS.)
NORM- WAITING	1,3281	% (TOT. WAIT TIME/TOT AC CAL. HRS.)
NORM- TOTAL	22,6432	% (TOT. DOWN TIME/TOT AC CAL. HRS.)
NORS - (INPUT)	7,0000	%
AVAILABILITY	70,3568	%

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AIRCRAFT =   47 ALTERNATE
CLASS = 1

PAYLOAD --------------- 23993 LBS
CRUISE SPEED (KMPH)
    INTERNAL ----------  259
    EXTERNAL ----------  238

CABIN COMPARTMENT
  FLOOR AREA -----------  240 SQ.FT.
  NUMBER OF SEATS ------   44
  NUMBER OF LITTERS ----   24
    AMBULATORY SEATS ---    2
```

MISSION			LEG			NUMBER OF		CARGO	INDV		
NO	TYPE	CLS	TYPE	NO	DIST	PAX	LITS	POUNDS	LOAD	SORTIES	FLT. HRS.
1	6	1	1	1	255	212872	0	65022720	1	4840	2.036
										4840	9853.164

NUMBER OF AIRCRAFT	16.	
UTILIZATION	52.49	HRS/AC/MO
MEAN TIME BETWEEN MAINTENANCE	0.7513	HOURS
TO & E SIZE	6	CREWS
MTTR	2.050	HOURS
EXPECTED QUEUE LENGTH	0.2125	TASKS
EXPECTED WAITING TIME FOR MEN	0.1277	HOURS
EXPECTED NO. TASKS. IN SYSTEM	3.6228	
EXPECTED TIME IN SYSTEM	2.1777	HOURS
PROBABILITY OF NO TASKS. IN SYSTEM	0.0319	
TOTAL WAITING TIME	142.7707	HOURS (FAILS. X EXP. WAIT TIME)
TOTAL DOWN TIME	2434.5100	HOURS (FAILS. X EXP. TIME IN SYS.)
NORM- WAITING	1.3279	% (TOT. WAIT TIME/TOT AC CAL. HRS.)
NORM- TOTAL	22.6424	% (TOT. DOWN TIME/TOT AC CAL. HRS.)
NORS - (INPUT)	7.0000	%
AVAILABILITY	70.3576	%

FLEET SIZING SUMMARY

	BASELINE	ALTERNATE
FLT. HRS. REQUIRED TO PERFORM MISSION	9849.09	9853.16
HOLDING AVAILABILITY CONSTANT :		
AVAILABILITY %	70.36	70.36
UTIL. (FH/AC/MO)	50.00	52.49
FLEET SIZE (AC)	196.98	187.70
HOLDING UTILIZATION CONSTANT :		
AVAILABILITY %	70.36	71.71
UTIL. (FH/AC/MO)	50.00	50.00
FLEET SIZE (AC)	196.98	197.06
HOLDING FLEET SIZE CONSTANT :		
AVAILABILITY %	70.36	71.69
UTIL. (FH/AC/MO)	50.00	50.02
FLEET SIZE (AC)	196.98	196.98

MODIFICATION INCORPORATION DATA - OLD STIFFNER

I N P U T S :

NO. OF MONTHS IN STUDY	180	
NO. OF COMPONENTS IN FLEET	296	
IRREG. DELIVERY RATE ?	NO	
IF CONSTANT, DELIVS. PER MO.	4	
NO. OF MONTHS	25	
AC DELIVERED WITH MOD ?	NO	
START MONTH	1	
IRREG. UTILIZATION ?	NO	
FLT. HRS./COMP./MO.	50	
TOTAL AC DELIV. WITH MOD	0	
IRREG. FIELD MOD INCORP. RATE ?	NO	
IF CONSTANT, INCORPS. PER MO.	0	
IF IRREG., NO. OF MONTHS	0	
TOTAL INCORPORATED	0	
START MONTH	0	
QTY. SPARES ON HAND	1	MONTHS
QTY. PIPELINE SPARES	4	MONTHS
COMP. ATTR. RATE/100000 HRS.	2.00	

	OLD ITEM	NEW ITEM
MTBF	206.02	292.65
MTBR TO AVIM	0.00	0.00
MTBR TO DEPOT	0.00	0.00

O U T P U T S :

	OLD ITEM	NEW ITEM
MAINT. ACTIONS AT		
AVUM	17008	0
AVIM	0	0
DEPOT	0	0
FLT. HRS.	3504000	0

INIT. SPARES REQ. PER LOC.	0
COMPS. ATTRITED	70

MODIFICATION INCORPORATION DATA - NEW STIFFNER

I N P U T S :

NO. OF MONTHS IN STUDY	180
NO. OF COMPONENTS IN FLEET	296
IRREG. DELIVERY RATE ?	NO
IF CONSTANT, DELIVS. PER MO.	4
NO. OF MONTHS	25
AC DELIVERED WITH MOD ?	YES
START MONTH	13
IRREG. UTILIZATION ?	NO
FLT. HRS./COMP./MO.	50
TOTAL AC DELIV. WITH MOD	52
IRREG. FIELD MOD INCORP. RATE ?	NO
IF CONSTANT, INCORPS. PER MO.	37
IF IRREG., NO. OF MONTHS	0
TOTAL INCORPORATED	344
START MONTH	13
QTY. SPARES ON HAND	1 MONTHS
QTY. PIPELINE SPARES	4 MONTHS
COMP. ATTR. RATE/100000 HRS.	2.00

	OLD ITEM	NEW ITEM
MTBF	206.02	292.65
MTBR TO AVIM	0.00	0.00
MTBR TO DEPOT	0.00	0.00

O U T P U T S :

	OLD ITEM	NEW ITEM
MAINT. ACTIONS AT		
AVUM	1368	11009
AVIM	0	0
DEPOT	0	0
FLT. HRS.	281950	3222050

INIT. SPARES REQ. PER LOC.	0
COMPS. ATTRITED	64

COST INPUT DATA - BASELINE

CONSTANT FACTORS :

OVERHEAD		180.00 %
G&A		17.00 %
PROFIT		10.00 %
SHIPPING RATE - CONTRACT		$ 17.00 PER 100 LBS.
IN-HOUSE		13.00 PER 100 LBS.
ARMY LABOR RATE - AVUM		10.00 PER HR.
AVIM		11.00 PER HR.
DEPOT		13.50 PER HR.
FUEL COST		0.45 PER GALLON
DISCOUNT RATE		10.00 %

OPERATING COST DATA :	OLD ITEM	NEW ITEM
% DEPOT MAINT. PERFORMED BY CONTR.	0 %	0 %
UNBURNDENED RATE	$ 0.00 PER HR.	$ 0.00 PER HR.
AVG. MMH TO REPAIR AT DEPOT	0.00	0.00
AVUM	8.90	0.00
AVIM	0.00	0.00
AVG. VALUE OF PARTS CONSUMED AT DEPOT	$ 0.00	$ 0.00
AVUM	5.00	0.00
AVIM	0.00	0.00
PART SHIPPING WEIGHT	0 LBS.	0 LBS.
SFC PER FLT. HR.	0.00 LBS.	0.00 LBS.

PROGRAM MGMT. COST PER YEAR :

1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0
11	0
12	0
13	0
14	0
15	0
16	0
17	0
18	0
19	0
20	0

COST INPUT DATA - ALTERNATE

CONSTANT FACTORS :

OVERHEAD	180.00 %	
G&A	17.00 %	
PROFIT	10.00 %	
SHIPPING RATE - CONTRACT	$ 17.00	PER 100 LBS.
IN-HOUSE	13.00	PER 100 LBS.
ARMY LABOR RATE - AVUM	10.00	PER HR.
AVIM	11.00	PER HR.
DEPOT	13.50	PER HR.
FUEL COST	0.45	PER GALLON
DISCOUNT RATE	10.00 %	

OPERATING COST DATA :

	OLD ITEM		NEW ITEM	
% DEPOT MAINT. PERFORMED BY CONTR.	0 %		0 %	
UNBURNDENED RATE	$ 0.00	PER HR.	$ 0.00	PER HR.
AVG. MMH TO REPAIR AT DEPOT	0.00		0.00	
AVUM	8.90		8.90	
AVIM	0.00		0.00	
AVG. VALUE OF PARTS CONSUMED AT DEPOT	$ 0.00		$ 0.00	
AVUM	5.00		5.00	
AVIM	0.00		0.00	
PART SHIPPING WEIGHT	0	LBS.	0	LBS.
SFC PER FLT. HR.	0.00	LBS.	0.00	LBS.

PROGRAM MGMT. COST PER YEAR :

1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0
11	0
12	0
13	0
14	0
15	0
16	0
17	0
18	0
19	0
20	0

COST INPUT DATA - ALTERNATE

		OVERHEAD ALREADY INCLUDED ?
R+D COSTS		
CONTRACT		
ENGINEERING	0.	NO
TOOLING	0.	NO
PROTOTYPE PRODUCTION	0.	NO
OTHER	0.	NO
G&A	0.	
PROFIT	0.	
QTY. OF PROTOTYPES	0.	
IN-HOUSE		
PROGRAM MGMT.	0.	
IF ELEMENTS NOT BROKEN OUT, TOTAL	0.	
ESTIMATE R&D COSTS ?	NO	
INVESTMENT NONRECURRING COSTS		
CONTRACT		
ADV PROD ENGINEERING	0.	NO
TOOLING	0.	NO
MANUFACTURING	0.	NO
QUALITY CONTROL	0.	NO
OTHER	0.	NO
G&A	0.	
PROFIT	0.	
IN-HOUSE		
PROGRAM MGMT.	0.	
IF ELEMENTS NOT BROKEN OUT, TOTAL	16027.	
ESTIMATE NONRECURRING COSTS ?	NO	
INVESTMENT RECURRING COSTS		
CONTRACT		
ENGINEERING	0.	NO
TOOLING	0.	NO
QUALITY CONTROL	0.	NO
MANUFACTURING	0.	NO
FIRST DEST. TRANSPORTATION	0.	
OTHER	0.	
G&A	0.	
PROFIT	0.	
IN-HOUSE		
TRANSPORTATION	0.	
PROGRAM MGMT.	0.	
TOTAL QTY.	450.	
IF ELEMENTS NOT BROKEN OUT, TOTAL	74963.	
ESTIMATE RECURRING COSTS ?	NO	

COST INPUT DATA - ALTERNATE

INVESTMENT COSTS BY YEAR :

YEAR	R&D	NON RECURRING	RECURRING
1	0	16027	0
2	0	0	2382
3	0	0	72581
4	0	0	0
5	0	0	0
6		0	0
7		0	0
8		0	0
9		0	0
10		0	0
11		0	0
12		0	0
13		0	0
14		0	0
15		0	0
16		0	0
17		0	0
18		0	0
19		0	0
20		0	0

OUTPUTS :		BASELINE			ALTERNATE		
1.0	RESEARCH & DEVELOPMENT	0.			0.		
1.01	CONTRACT		0.			0.	
1.011	ENGINEERING			0.			0.
1.012	TOOLING			0.			0.
1.013	PROTOTYPE PRODUCTION			0.			0.
1.014	OTHER			0.			0.
1.015	G. & A			0.			0.
1.016	PROFIT			0.			0.
1.017	QUANTITY OF PROTOTYPES			0.			0.
1.02	IN-HOUSE		0.			0.	
1.024	PROGRAM MANAGEMENT			0.			0.
				0.			0.
				0.			0.
2.0	INVESTMENT NONRECURRING	0.			16027.		
2.01	CONTRACT		0.			0.	
2.011	ADV PROD ENGINEERING			0.			0.
2.012	TOOLING			0.			0.
2.013	MANUFACTURING			0.			0.
2.014	QUALITY CONTROL			0.			0.
2.015	OTHER			0.			0.
2.016	G & A			0.			0.
2.017	PROFIT			0.			0.
2.02	IN-HOUSE		0.			0.	
2.023	PROGRAM MANAGEMENT			0.			0.
				0.			0.
				0.			0.
3.0	INVESTMENT RECURRING	0.			74963.		
3.01	CONTRACT		0.			0.	
3.011	ENGINEERING			0.			0.
3.012	TOOLING			0.			0.
3.013	QUALITY CONTROL			0.			0.
3.014	MANUFACTURING			0.			0.
3.016	FIRST DEST TRANSPORT			0.			0.
3.017	OTHER			0.			0.
3.018	G & A			0.			0.
3.019	PROFIT			0.			0.
3.02	IN-HOUSE		0.			0.	
3.025	TRANSPORTATION			0.			0.
3.026	PROGRAM MANAGEMENT			0.			0.
3.03	TOTAL QUANTITY		0.			450.	
				0.			0.
				0.			0.
4.0	OPERATING COSTS	1598751.			1163437.		
4.01	CONTRACT		0.			0.	
4.012				0.			0.
4.015	TRANSPORTATION			0.			0.
4.016	DEPOT MAINTENANCE			0.			0.
4.017	OTHER			0.			0.
4.02	IN-HOUSE		1598751.			1163437.	
4.021	MAINTENANCE LABOR			1513711.			1101552.
4.022	CONSUMPTION			85040.			61885.
4.0221	PARTS			85040.			61885.
4.0222	POL			0.			0.
4.025	TRANSPORTATION			0.			0.
4.026	DEPOT MAINTENANCE			0.			0.
4.027	PROGRAM MANAGEMENT			0.			0.
4.03	TOTAL QTY OPERATED		396.			396.	

BEST AVAILABLE COPY

	BASELINE			ALTERNATE							
YEAR	ANNUAL COST	CUM. COST	PRESENT VALUE	ANNUAL COST	CUM. COST	PRESENT VALUE	ANNUAL O&M COSTS	CUM O&M COSTS	OLD ITEMS	NEW ITEMS	TOTAL ITEMS
1	88078.	88078.	83979.	104105.	104105.	99260.	88078.	88078.	344	0	344
2	101332.	189410.	171812.	85666.	189771.	173514.	83284.	171362.	0	392	392
3	108382.	297792.	257215.	148909.	338680.	290852.	76328.	247690.	0	396	396
4	108382.	406174.	334855.	76328.	415008.	345530.	76328.	324018.	0	396	396
5	108476.	514650.	405498.	76234.	491242. *	395176. #	76234.	400252.	0	396	396
6	108382.	623032.	469663.	76328.	567570.	440364.	76328.	476580.	0	396	396
7	108382.	731414.	527995.	76328.	643898.	481444.	76328.	552908.	0	396	396
8	108476.	839890.	581069.	76328.	720226.	518790.	76328.	629236.	0	396	396
9	108382.	948271.	629278.	76328.	796553.	552740.	76328.	705563.	0	396	396
10	108382.	1056653.	673103.	76328.	872881.	583604.	76328.	781891.	0	396	396
11	108382.	1165034.	712945.	76328.	949209.	611663.	76328.	858219.	0	396	396
12	108476.	1273509.	749196.	76328.	1025537.	637170.	76328.	934547.	0	396	396
13	108382.	1381890.	782123.	76328.	1101865.	660359.	76328.	1010875.	0	396	396
14	108382.	1490271.	812056.	76328.	1178192.	681440.	76328.	1087203.	0	396	396
15	108476.	1598746.	839292.	76234.	1254425.	700580.	76234.	1163436.	0	396	396

* = BREAK EVEN POINT, (COSTS NOT DISCOUNTED).
# = BREAK EVEN POINT, (PRESENT VALUE).

	BASELINE	ALTERNATE
CUMULATIVE CASH FLOW, ACTUAL	1598746.	1254425.
PRESENT VALUE OF CASH FLOW	839292.	700580.
INVESTMENT (PRESENT VALUE)		74539.
TRUE RATE OF RETURN ON INVESTMENT		11.17 %